

Attachment H

Proposal # 2001- L-204 (Office Use Only)

PSP Cover Sheet (Attach to the front of each proposal)

Proposal Title: Fish Treadmill-Developed Fish Screen Criteria for Native Sacramento-San Joaquin Watershed Fishes
 Applicant Name: Joseph J. Cech, Jr.
 Contact Name: Joseph J. Cech, Jr.
 Mailing Address: Dept. of Wildlife, Fish, and Conservation Biology, Univ. of Califo
 Telephone: (530) 752-3103 Davis, CA 95616
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Amount of funding requested: \$ \$1,786,605 (@10%), \$ \$2,271,463 (@46.5-48%)

Some entities charge different costs dependent on the source of the funds. If it is different for state or federal funds list below.

State cost \$1,786,605 Federal cost \$2,271,463

Cost share partners?

☒ Yes ☐ No

Identify partners and amount contributed by each UC Davis, \$24,478

Indicate the Topic for which you are applying (check only one box).

- | | |
|--|--|
| <input type="checkbox"/> Natural Flow Regimes | <input type="checkbox"/> Beyond the Riparian Corridor |
| <input type="checkbox"/> Nonnative Invasive Species | <input type="checkbox"/> Local Watershed Stewardship |
| <input type="checkbox"/> Channel Dynamics/Sediment Transport | <input type="checkbox"/> Environmental Education |
| <input type="checkbox"/> Flood Management | <input type="checkbox"/> Special Status Species Surveys and Studies |
| <input type="checkbox"/> Shallow Water Tidal/ Marsh Habitat | <input type="checkbox"/> Fishery Monitoring, Assessment and Research |
| <input type="checkbox"/> Contaminants | <input checked="" type="checkbox"/> Fish Screens |

What county or counties is the project located in? Yolo County

What CALFED ecozone is the project located in? See attached list and indicate number. Be as specific as possible 1, 10 (results applicable to ecozones 1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, and 13)

Indicate the type of applicant (check only one box):

- | | |
|--|---|
| <input type="checkbox"/> State agency | <input type="checkbox"/> Federal agency |
| <input type="checkbox"/> Public/Non-profit joint venture | <input type="checkbox"/> Non-profit |
| <input type="checkbox"/> Local government/district | <input type="checkbox"/> Tribes |
| <input checked="" type="checkbox"/> University | <input type="checkbox"/> Private party |
| <input type="checkbox"/> Other: _____ | |

Indicate the primary species which the proposal addresses (check all that apply):

- | | |
|---|---|
| <input checked="" type="checkbox"/> San Joaquin and East-side Delta tributaries fall-run chinook salmon | <input checked="" type="checkbox"/> Spring-run chinook salmon |
| <input checked="" type="checkbox"/> Winter-run chinook salmon | <input checked="" type="checkbox"/> Fall-run chinook salmon |
| <input checked="" type="checkbox"/> Late-fall run chinook salmon | <input checked="" type="checkbox"/> Longfin smelt |
| <input checked="" type="checkbox"/> Delta smelt | <input checked="" type="checkbox"/> Steelhead trout |
| <input checked="" type="checkbox"/> Splittail | <input checked="" type="checkbox"/> Striped bass |
| <input checked="" type="checkbox"/> Green sturgeon | <input checked="" type="checkbox"/> All chinook species |
| <input checked="" type="checkbox"/> White Sturgeon | <input checked="" type="checkbox"/> All anadromous salmonids |
| <input type="checkbox"/> Waterfowl and Shorebirds | <input checked="" type="checkbox"/> American shad |
| <input type="checkbox"/> Migratory birds | |
| <input type="checkbox"/> Other listed T/E species: _____ | |

Indicate the type of project (check only one box):

- | | |
|---|---|
| <input checked="" type="checkbox"/> Research/Monitoring | <input type="checkbox"/> Watershed Planning |
| <input type="checkbox"/> Pilot/Demo Project | <input type="checkbox"/> Education |
| <input type="checkbox"/> Full-scale Implementation | |

Is this a next-phase of an ongoing project? Yes xxx No _____
Have you received funding from CALFED before? Yes xxx No _____

If yes, list project title and CALFED number Fish Treadmill-Developed Fish Screen Criteria for Native Sacramento-San Joaquin Watershed Fishes, #99-N02

Have you received funding from CVPIA before? Yes _____ No xxx

If yes, list CVPIA program providing funding, project title and CVPIA number (if applicable):

By signing below, the applicant declares the following:

- The truthfulness of all representations in their proposal;
- The individual signing the form is entitled to submit the application on behalf of the applicant (if the applicant is an entity or organization); and
- The person submitting the application has read and understood the conflict of interest and confidentiality discussion in the PSP (Section 2.4) and waives any and all rights to privacy and confidentiality of the proposal on behalf of the applicant, to the extent as provided in the Section.

JOSEPH J. CECI, JR.

Printed name of applicant

Joseph J. Ceci Jr.

Signature of applicant



smdowdy@ucdavis.edu
OFFICE OF THE VICE CHANCELLOR FOR RESEARCH
(530) 752-2075
FAX: (530) 752-5432

410 Mrak Hall, One Shields Avenue
DAVIS, CALIFORNIA 95616-8671

CALFED Bay-Delta Program Office
1416 Ninth Street, Suite 1155
Sacramento, CA 95814

MAY 12 2000

Dear Colleague:

2001 Proposal Solicitation

Proposal Entitled "Fish Treadmill-Developed Fish Screen Criteria for
Native Sacramento-San Joaquin Watershed Fishes"
Principal Investigator: Joseph J. Cech, Jr.

It is a pleasure to present for your consideration the referenced proposal.

Following the direction of "**Attachment D - Terms and Conditions for State Proposition 204 Funds**", this is to provide notification that the applicant takes exception to the following proposed "standard" clauses:

Section 6. Substitution
Section 9. Rights in Data
Section 11. Indemnification, and
Standard Clauses-Insurance Requirements - DWR

In order to bring the above provisions into conformity with the University of California Policy, we reserve the right to discuss with the aim of properly modifying these sections, should this proposal result in a subsequent award.

Please contact the principal investigator for scientific information. Administrative questions may be directed to my assistant, Ms. Petrina Ho, or me by telephone, facsimile or electronic mail at the numbers cited above. Furthermore, correspondence pertaining to this proposal and any subsequent award should be sent to the Office of Research and to the principal investigator.

Sincerely,

A handwritten signature in cursive script that reads "Sandra M. Dowdy".
Sandra M. Dowdy
Contracts & Grants Analyst

Enclosures
Cc: J. Cech

Proposal to:

Name CALFED Bay/Delta Program
Address 1416 Ninth Street, Suite 1155
Sacramento, CA 95814

Submitting Organization:

THE REGENTS OF THE UNIVERSITY OF CALIFORNIA
UNIVERSITY OF CALIFORNIA
ONE SHIELDS AVENUE
DAVIS, CALIFORNIA 95616

Title of Proposed Research: Fish Treadmill-Developed Fish Screen Criteria for
Native Sacramento-San Joaquin Watershed Fishes

Total Amount Requested:

\$1,786,605 (@10%)
\$2,271,463 (@46.5-48%)

Proposed Duration:

24 months

Desired Starting Date:

4-01-01

Principal Investigator/

Co-Investigator(s):

J. J. Cech, Jr.
M. L. Kavvas
G. Aasen

Department:

WFCB
Civil Env. Engin.
CA Dep. Fish&Game

Phone Number:

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(530) 752-2518
(209) 948-7800

Checks Made Payable to:

The Regents of the University of California

Send Checks to:

CASHIER'S OFFICE
UNIVERSITY OF CALIFORNIA
ONE SHIELDS AVENUE
DAVIS, CA 95616

Send Award Notice to:

OFFICE OF RESEARCH
UNIVERSITY OF CALIFORNIA
ONE SHIELDS AVENUE
DAVIS, CA 95616
(530) 752-2075

Approvals:

Joseph A. Cech, Jr. 5-12-00

Principal Investigator

Date

Co-Investigator

Date

Co-Investigator

Date

Department Chair

Date

Dean, College/School

Date

Sandra M. Dowdy
Official Signing for Organization

MAY 12 2000

B. Executive Summary

Title FISH TREADMILL-DEVELOPED FISH SCREEN CRITERIA FOR NATIVE SACRAMENTO-SAN JOAQUIN WATERSHED FISHES

Amount Requested \$2,271,637 (at 46.5-48% federal overhead rate, or \$1,786,605 at 10% state overhead rate) for two years (4/1/01-3/31/03)

Applicant Joseph J. Cech, Jr.
Department of Wildlife, Fish, and Conservation Biology
University of California, Davis
(530) 752-3103, FAX (530) 752-4154, email: jjcech@ucdavis.edu

Participants and Collaborators M. Levent Kavvas, Dept. of Civil and Environmental Engineering, UC Davis
U.S. Bureau of Reclamation
California Department of Fish and Game

The Fish Treadmill project is an ongoing, multi-agency, targeted research program that addresses the uncertain impacts of water diversions and fish screens on priority fish species (e.g., delta smelt, splittail, chinook salmon, steelhead). The project objective is to provide the data necessary to evaluate and improve aspects of fish protective facility design and operation at the State Water Project (SWP), Central Valley Project (CVP, including the Tracy Fish Test Facility, TFTF), and other existing and proposed fish screen facilities (e.g., Hood-Mokelumne Connection). This proposal requests next-phase funding to continue this valuable research program and to expand its scope to include other priority fish species (e.g., sturgeon) and complementary investigations on the effects of debris on fish screen function and fish-fish screen interactions.

Installation of fish screens and improvements to existing fish screen facilities have been identified by CALFED as activities that provide direct benefits to fish resources, habitats, and ecosystem processes by reducing stressors associated with water diversions. However, for many priority species (e.g., delta smelt, splittail), present fish screen criteria, largely developed using data from non-priority species, may be inadequate. The Fish Treadmill project was specifically proposed and designed by cooperative, multi-agency partners to address these information gaps for priority species and to provide timely, relevant, and comprehensive data that could be applied to design, operate, and adaptively manage screened water diversions that more effectively protect fish resources. This work focuses on near-field effects (i.e., near-screen effects), evaluating fish screen and flow impacts on fish survival and passage and correlating them with screen design and operational criteria (i.e., screen flow velocity), fish screen function (e.g., effects of debris loading), species and life history stage (e.g., fish size), and environmental conditions (e.g., day vs night).

The Fish Treadmill project addresses CALFED and CVPIA goals, including at-risk species recovery and conservation (CALFED Goal 1), protection and recovery of harvestable species (CALFED Goal 3), successful implementation of the CVPIA fish protection and fish doubling goals, and non-ecosystem benefits like water supply reliability. Continuation of the project has multi-agency support, including CALFED, DWR, DFG, USBR, NMFS, and USFWS.

The principal investigator, Dr. Joseph J. Cech, Jr., is Principal Investigator for the ongoing Fish Treadmill program. All other staff, including co-investigators Drs. M. L. Kavvas (supervisor, Fish Treadmill operation), Paciencia S. Young (managing biologist, Fish Treadmill biological studies), and Z. Q. Chen (managing engineer, Fish Treadmill operation), participated in the development of the Fish Treadmill project and are presently actively involved in the program.

C. PROJECT DESCRIPTION (8 pages, excluding Figures and Tables)

1. Statement of the Problem

a. Background and Rationale

The Fish Treadmill project is an ongoing targeted research program that directly addresses the uncertain impacts of water diversions and fish screens on fishes. The objective of the project is to provide the data necessary to evaluate and improve aspects of fish protective facility design and operation at the State Water Project (SWP), Central Valley Project (CVP, including the Tracy Fish Test Facility, TFTF), and other existing and proposed fish screen facilities (e.g., Hood-Mokehumne Connection). The Fish Treadmill project is presently providing rigorous, quantitative data on effects of screen flow (i.e., combinations of approach and sweeping velocity) and environmental conditions (temperature, day vs night) on the behavior and survival of priority species, including delta smelt, splittail, chinook salmon and steelhead, near a fish screen. With this proposal, we request next-phase funding to continue these studies and to expand the scope of the project to include other species (e.g., sturgeon) and complementary investigations of other aspects of water diversion and fish screen impacts identified by CALFED as probable contributors to the adverse impacts of this stressor.

Installation of fish screens and improvements to existing fish screen facilities have been recognized by CALFED as activities that provide direct benefits to fish resources and the ecosystem by reducing stressors associated with water diversions. The Ecosystem Restoration Program Plan (ERPP, Vol. 1, p. 425) contends that a "well-designed fish screen based on proven technology is effective in reducing entrainment and impingement losses of many species of juvenile fish". However, for most native fishes of the Sacramento-San Joaquin system, including priority listed species like delta smelt and splittail, there is no "proven technology". For these species (and others of concern), present fish screen criteria, developed from limited studies with salmonids and non-native fishes, may be inadequate and confer no protection from entrainment and impingement, or overly protective and thus unnecessarily costly to water diverters. In addition, optimal fish screen design and operation is almost certainly complicated by other factors, for example debris loading and its unknown effects on fish screen function and (presumed) corresponding changes in fish survival and passage. This question has not been addressed empirically for any local fish species and thus adds another uncertainty to the larger issue of water diversion impacts and functional, protective fish screen design and operation.

The importance of fish screen flow criteria and their potential differential impacts on survival and passage of Delta fishes is already indicated by preliminary results from the Fish Treadmill project (most recently described in a draft report to DWR, Swanson et al., 1999). Based in part on these reports, several CALFED member agencies engaged in fish facility development and improvement, including U.S. Bureau of Reclamation (USBR), Department of Water Resources (DWR), Department of Fish and Game (DFG), U.S. Fish and Wildlife (USFWS) and National Marine Fisheries Service (NMFS), have suggested a variety of design and operational solutions to address identified protection and passage issues, for example, determining optimal sweeping velocity (i.e., flow parallel to the screen) to promote near-screen passage. We propose to use the Fish Treadmill, the only operational flume capable of testing delicate priority species like delta smelt, to continue this critical work and to investigate specific aspects of some of these suggested solutions, with an emphasis on quantitative biological studies with Delta species, rigorous experimental designs, state-of-the-art methods, and a proven targeted research approach.

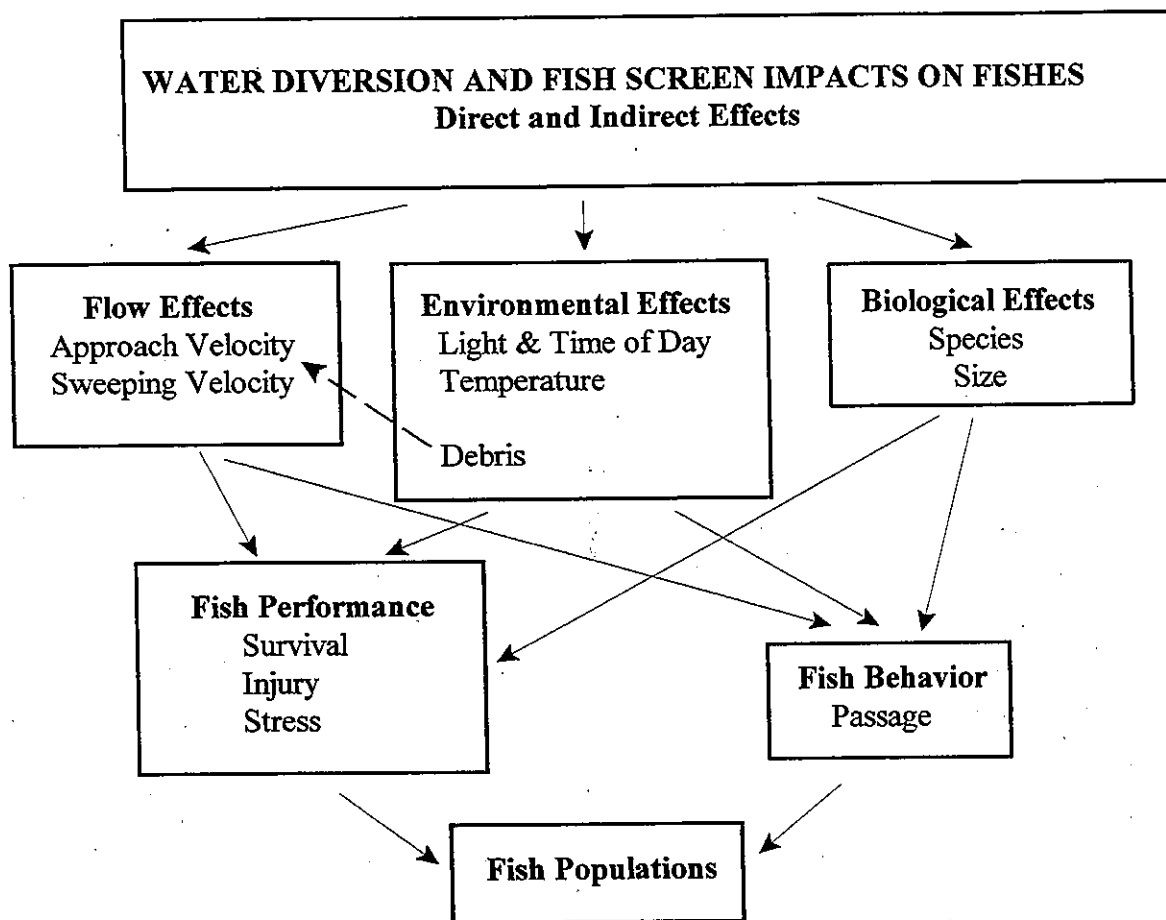


Figure 1. Conceptual model identifying relationships among those factors and mechanisms hypothesized to influence near-field water diversion and fish screen impacts on fish populations.

b. Conceptual Model and Hypotheses to be Tested

The ongoing Fish Treadmill project and proposed next-phase targeted research program directly address a major area of uncertainty identified by CALFED, the impacts of water diversions and fish screens on Sacramento-San Joaquin watershed fishes. This work focuses on near-field effects (i.e., near-screen effects), evaluating the magnitude of these impacts on fish survival and passage and correlating them with fish screen design and operational criteria (i.e., screen flow velocity, exposure duration), fish screen function (e.g., effects of debris loading), species and life history stage (e.g., fish size), and environmental conditions (e.g., day vs night).

By developing the data and technology to reduce water diversion impacts, the Fish Treadmill project has links to CALFED goals and other ecosystem elements, including at-risk species recovery and conservation (CALFED Goal 1), protection and recovery of harvestable species (CALFED Goal 3), successful implementation of the CVPIA fish protection and fish doubling goals, and non-ecosystem benefits like water supply reliability.

The conceptual model and hypotheses to be tested with the proposed targeted research program are outlined in Figure 1 above and Table 1 on the following page.

Table 1. Targeted research approach to test hypotheses on the magnitude and mechanisms of near-field water diversion and fish screen impacts on fish populations in the Sacramento-San Joaquin watershed.

TARGETED RESEARCH APPROACH TO EVALUATE WATER DIVERSION AND FISH SCREEN IMPACTS ON FISHES

Problem: Quantify and identify mechanisms for near-field water diversion and fish screen impacts on fishes.

Conceptual Model: Water diversions and fish screens impact fishes through direct screen effects (e.g., adverse fish-fish screen interactions) and indirect screen effects (e.g., adverse impacts on fishes near fish screen through other factors).

Mechanisms:

1. Direct screen effects (e.g., screen contact, impingement, mortality, injury, stress).
2. Debris effects on screen function (e.g., variations in screen flow hydraulics, interference with fish behavior).

Hypotheses to examine proposed mechanisms (mechanisms 1 and 2 as identified above):

- 1.a. Screen flow velocity (i.e., combined approach and sweeping velocity) affects frequency of screen contact, impingement, and survival.
- 1.b. Screen flow velocity affects fish passage (and therefore screen exposure duration).
- 1.c. Screen flow velocity effects on mortality, injury, stress, and screen passage vary among species, life history stage, and environmental conditions (i.e., temperature, time of day, light level).
- 2.a. Debris affects screen flow hydraulics (e.g., increased spatial variation in near-screen approach velocity).
- 2.b. Variations in screen flow hydraulics affect near-screen fish performance and behavior (e.g., survival, screen contact and impingement frequency, passage velocity).
- 2.c. Debris-related effects vary among species, life history stage, and environmental conditions (i.e., temperature, time of day, light level).

c. Adaptive Management

This targeted research approach and use of the laboratory-based Fish Treadmill apparatus for biological evaluations of water diversion and fish screen impacts on Sacramento-San Joaquin watershed fishes is more likely to resolve the identified uncertainties than field-based pilot studies, implementation projects, or other fish facility-based programs (e.g., Tracy Fish Test Facility, TFTF or Glenn-Colusa Irrigation District, GCID) for several reasons.

1. The Fish Treadmill is uniquely capable of testing fish under a wide range of approach and sweeping flow combinations (e.g., high approach velocity combined with low sweeping velocity or low approach velocity combined with high sweeping velocity) and thus provides opportunities for detailed examinations of the interactive effects of multiple flow vectors. As such, it is the only research platform capable of providing the data necessary to develop fish

screen criteria for both "on-river" and "off-river" screens. For example, preliminary results with delta smelt have suggested that both flow vectors significantly and independently affect protection (e.g., survival) and passage (i.e., velocity past screen and thus exposure duration).

2. Flow and environmental conditions (e.g., temperature, light levels, debris load) can be precisely controlled and reproduced in the Fish Treadmill, enabling the replication of experimental treatments necessary for statistical analyses to isolate and detect significant effects of specific factors. Environmental conditions in the field or at large facilities are inherently uncontrolled and variable, and cannot be replicated. Further, experimental (e.g., flow velocity, debris load) and environmental parameters (e.g., temperature, light level) can be easily altered and manipulated in this laboratory-based test facility, providing both the capability and opportunities for modification of hypotheses, experimental design, and approach as data and results indicate.

3. Detailed observations of fish behavior (e.g., frequency of contact with the screen, swimming behavior, velocity past screen) provide valuable information on important aspects of fish performance and behavior near fish screens and the magnitude and mechanisms of their impact on fishes, particularly when correlated with complementary data in survival, injury and stress. Observations of fishes near fish screens installed at water diversions in the Delta (e.g., TFTF) or on rivers (e.g., Glenn-Colusa Irrigation District, GCID) are logistically and technically difficult because turbid water conditions limit visibility for human or video observations. Further, artificial introduction and post-exposure collection of test fish at a field and/or large-scale diversion is difficult and probably more stressful to the fish than the experimental treatment. Thus, the effects of exposure to the fish screen and specified experimental conditions cannot be easily separated from the stressful effects of field handling.

4. The Fish Treadmill is the **only** large scale fish screen test facility capable of testing delicate, high priority native species (e.g., delta smelt) under realistic, controlled flow and environmental conditions, and providing detailed quantitative data for the development of fish screen criteria and improved operations. It is presently fully operational, calibrated for a wide range of flow conditions, and staffed with qualified, trained personnel.

d. Educational Objectives

Although the project is targeted research, several UC Davis graduate and undergraduate students will be part of the research team. Regular reports at workshops, meetings, and in the IEP Newsletter, and peer-reviewed publications will help disseminate results to the interested public and to professionals.

2. Proposed Scope of Work

a. Location and Geographic Boundaries

The proposed project, continuation of laboratory-based, targeted fish screen research, will occur at the University of California, Davis, Hydraulics Laboratory located in Yolo County. The results of this research will be applicable to stressors, habitats, and species that are located in 11 of the 14 Sacramento-San Joaquin watershed Ecological Management Zones identified by CALFED to contain screened and unscreened water diversions, proposed new water diversions (e.g., for new off-stream storage, Sacramento River), and/or existing water diversions for which new or upgraded fish screens are proposed (e.g., Clifton Court Forebay at the SWP, Tracy Fish Facility at the CVP) (ERP, Vol. 1, p 424). The quantitative data generated by this project will be immediately applicable and complementary to ongoing and proposed field evaluations of large

screened diversions (e.g., Tracy Fish Facility Improvement Program, GCID screen evaluation program, Hood-Mokelumne Connection). In addition, the results of this project will be broadly applicable to Interagency Ecological Program agency and CALFED decision makers to assess and predict the beneficial effects of various screening strategies for proposed CALFED alternatives.

b. Approach

The experimental design, methods and data evaluation approach of the Fish Treadmill Project are complicated with many experimental variables and many measurements made during each experiment. Therefore, the overall experimental approach is presented in tabular form. Experimental variables and monitoring parameters are outlined in Table 2 and the data collection and data evaluation approach in Table 3 (following pages).

During the period for which funding is requested, we will conduct experiments with the following species:

- **delta smelt**, juveniles and adults, collected from Sacramento-San Joaquin estuary
- **steelhead**, parr, collected from state and federal hatcheries
- **splittail**, young-of-the-year (YOY), collected from Sacramento-San Joaquin estuary and state and federal fish facilities
- **chinook salmon**, parr and smolts, collected from state and federal hatcheries
- **green sturgeon**, YOY, hatched and reared at UC Davis, fertilized eggs provided by Yurok Tribe, Trinity and Klamath Rivers
- **white sturgeon**, YOY, hatched and reared at UC Davis
- **American shad**, YOY, collected from Sacramento-San Joaquin estuary and state and federal fish facilities

If fish are available and time permits, we will also conduct experiments with other species, for example:

- **striped bass**, YOY, collected from Sacramento-San Joaquin estuary and state and federal fish facilities
- **longfin smelt**, juveniles and adults, collected from Sacramento-San Joaquin estuary and state and federal fish facilities

Two types of experiments using the Fish Treadmill are proposed.

1. Effects of Flow and Environmental Conditions: Effects of flow (i.e., ten combinations of approach and sweeping velocities, see Table 2) and environmental conditions (i.e., temperature, light level/time of day, see Table 2) on performance and behavior of fish species listed above (Note: For splittail, chinook salmon, and delta smelt, these experiments are near completion. See Appendix 1 for description of current status of the ongoing Fish Treadmill project, including status and progress of CALFED-funded portions of the work.) In addition, if time and fish availability permit, a limited number of experiments in which the flow velocity in the Fish Treadmill is increased gradually from 0 ft/s to selected target levels ("gradual flow increase" experiments; see Swanson et al. 1998a for complete description of experimental protocol and preliminary results of experiments with splittail and chinook salmon) will be also conducted.

2. Effects of Debris: Effects of debris loading on fish screen function and fish behavior and performance at selected flow and environmental conditions (e.g., three or four approach/sweeping velocity combinations during both day and night). Data from these experiments will be compared with that from "regular" Fish Treadmill experiments (i.e., Type 1 above) at similar flow and environmental conditions.

Table 2. Experimental variables and monitoring parameters used in the Fish Treadmill experiments.

FLOW (ft/s) (10 flow treatments, one control and nine experimental)	<i>Approach</i> 0 (control) 0.2 (6 cm/s) 0.33 (10cm/s) 0.5 (15 cm/s) 0.2 0.33 0.5 0.2 0.33 0.5	<i>Sweeping</i> 0 (control) 0 0 0 1.0 (31cm/s) 1.0 1.0 2.0 (62 cm/s) 2.0 2.0
TEMPERATURE	12°C: winter and spring 19°C: summer and fall	
TIME OF DAY/ LIGHT LEVEL	Day, light level: 200-300 lux Night, light level: 0-1 lux	
FISH SIZE	small: <6.0 cm SL medium: 6.0-8.0 cm SL	
DEBRIS LOAD	0 and 33% occluded using simulated debris	
<hr/>		
NUMBER OF FISH PER EXPERIMENT	20 fish	(All fish used only one time in the Fish Treadmill experiments.)
EXPERIMENT DURATION	2 hours	
POST-EXPERIMENTAL EVALUATION	48 hours	(Some fish sampled for stress responses during the post-experimental period.)
REPLICATES PER TREATMENT	3 replicates	

Table 3. Measurements made during each Fish Treadmill experiment.

<i>Measurement type</i>	<i>Definition</i>	<i>Method</i>
FLOW and ENVIRONMENTAL CONDITIONS		
Approach and Sweeping velocity	ft/s and cm/s	3-D acoustic doppler velocimeter, Measured at beginning and end of each experiment
Temperature	°C	Measured at beginning and end of each experiment
Dissolved oxygen	mg/l	Measured at beginning and end of each experiment
Light level	lux	Measured at beginning of each experiment
Debris load	% occlusion	Measured one time at calibration
PERFORMANCE		
Impingement	prolonged (>5 min) contact with screen	measured visually throughout experiment
Screen contact	temporary contact with screen	measured visually throughout experiment
Survival	-----	measured at 0 and 48 h post-experimental
Injury	damage to skin, scales, fins, eyes	measured 48 h post-experimental
BEHAVIOR		
Swimming velocity		measured using computer-assisted motion analysis of video tapes
over the ground	cm/s, velocity past screen	
through the water	cm/s, swimming velocity	
Orientation (rheotaxis)	orientation relative to resultant current	
Distance from screen	distance (cm) from inner fish screen	
Schooling	distribution of fish in swimming channel	measured visually throughout experiment
PHYSIOLOGICAL RESPONSES		
Hematocrit (% red blood cells)		
Plasma variables		
pH		Measured from pooled blood (samples collected from two randomly selected fish at selected post-experimental times)
lactate concentration		
glucose concentration		
chloride ion concentration (or osmolality)		
cortisol concentration		

c. Monitoring and Assessment Plan

Biological studies with the Fish Treadmill are ongoing and, for the period of February 16, 2000 through March 31, 2001, supported by CALFED (Project # 99-N02, Program Manager: Spencer Shepherd, National Fish and Wildlife Foundation). The experimental approach, design, methods, and analyses have already been subjected to rigorous discussion and review. Descriptions of the work and preliminary results for delta smelt, splittail, and chinook salmon have been reported in several technical reports (Velagic et al., 1998; Swanson et al. 1998a, 1999; Hayes et al., 2000), IEP Newsletter articles, and presentations at technical and scientific meetings. Detailed descriptions of all aspects of the project are provided in the Fish Treadmill Quality Assurance Project Plan (QAPP, Swanson et al. 1998b) and the Biological Monitoring/Research Plan (BM/RP) submitted to CALFED earlier this year and attached as Appendix II. This document will be updated to incorporate information and monitoring/assessment protocols required for the new types of studies (e.g., research with previously untested species, investigations of effects of debris loading) proposed for this next-phase research program.

d. Data Handling and Storage

Data handling and storage are described in the Fish Treadmill Biological Monitoring/Research Plan, attached as Appendix II. These protocols will be updated as necessary for this next-phase research program.

e. Expected Products and Outcomes

Quarterly reports will include financial status, activities during the quarter, tasks completed, deliverables produced, problems encountered, and a description of modifications to the contract.

Technical reports describing results of the two proposed types of studies will be submitted within two months of completion of that study or, at a minimum, annually. A final technical report will be submitted by May 31, 2003.

Status and results of the project will also be presented and discussed at bi-annual meetings of the Interagency partners, UC Davis research staff, outside consultants, and other interested parties.

Results of these studies have been and will continue to be presented at scientific and technical meetings. As an example, reports on Fish Treadmill project results for several species were presented in the Fish Passage Symposium at the Annual Meeting of the California-Nevada Chapter of the American Fisheries Society (April 29-May1, 2000, Ventura, CA) and are scheduled for presentation at the International Congress on the Biology of Fishes, Fish Migration and Passage Symposium, later this year (July 23-26, 2000, Aberdeen, UK).

Results of these studies will also be described in IEP Newsletter articles (one or two articles per year), and in manuscripts submitted for publication in peer-reviewed scientific journals (e.g., Transactions of the American Fisheries Society, North American Journal of Fishery Management, Environmental Biology of Fishes, Copeia, Journal of Experimental Biology, Conservation Biology, Hydrobiologia, and Water Research). Several manuscripts based on results of Fish Treadmill studies with several species (e.g., chinook salmon, splittail, delta smelt) are presently in preparation.

All data will be stored by the Principal Investigator for a minimum of five years after project completion.

f. Work Schedule

Funding for this next-phase targeted research is requested for a two-year period beginning April 1, 2001 (March 31, 2001 is the end date for current CALFED funding, Project # 99-N02). The proposed work and schedule outlined below are based on year-round Fish Treadmill operation and research, successful completion of an average of 4.5 experiments/week (a work rate consistent with that achieved during the past 2.5 years of Fish Treadmill studies), and contingent on adequate funding, personnel, and fish availability. For this period, four tasks are identified (Table 4, and see F. Cost, for specific activities involved in these tasks).

Table 4. Tasks and schedule for proposed Fish Treadmill project.

TASK	SCHEDULE
Task 1. Operation, Maintenance, and Calibration of the Fish Treadmill	April 2001 - February 2003
Task 2. Biological Experiments Using the Fish Treadmill	April 2001 - February 2003
Task 3. Fish Collection	April 2001 - December 2002
Task 4. Project Management	April 2001 - March 2003

Unlike field-based studies that are subject to unpredictable and variable seasonal conditions, the Fish Treadmill is capable of year-round operation and active research (Tasks 1 and 2). The schedule of experiments for each species (Table 5) is determined by species priority rank (e.g., delta smelt have higher priority than striped bass YOY), seasonal availability (most species are available in the appropriate sizes during limited seasonal periods), and the numbers and types of experiments required to complete experimental datasets defined in the Fish Treadmill experimental design and project plan outlined in the Biological Monitoring/Research Plan (Appendix II, and see Appendix 1 for present status of Fish Treadmill studies). Preliminary data analysis is conducted concurrently with the experiments. Final data analyses and preparation of the final technical report(s) will be completed as specified in section e. Expected Products and Outcomes above. Fish collection (Task 3) is conducted on an "as needed" basis for each species. Project management (Task 4) will be conducted by the Principal Investigator, J. J. Cech, Jr. (UC Davis, Biological Studies), post-doctoral researcher P. S. Young (Biological Studies), and co-investigators M. L. Kavvas (UC Davis, Fish Treadmill Operation) and G. Aasen (DFG, Interagency liaison and Fish Collection).

Table 5. Schedule for proposed Fish Treadmill experiments.

EXPERIMENT TYPE	SPECIES	SCHEDULE
Effects of Flow and Environmental Conditions	delta smelt	winter, 2002
	splittail	spring, 2001
	chinook salmon	spring, 2001
	steelhead trout	spring, 2001 and 2002
	green sturgeon	spring, 2001 and 2002
	white sturgeon	summer/fall, 2001 and 2002
	American shad	summer/fall, 2001 and 2002
	other species	as availability and time permit
Effects of Debris	delta smelt	summer/fall, 2001 and 2002; winter, 2002 and 2003
	splittail	spring/summer/winter, 2001 and 2002
	chinook salmon	spring/summer/fall, 2001 and 2002
	steelhead	spring, 2001 and 2002
	green sturgeon	spring, 2001 and 2002
	white sturgeon	summer/fall, 2001 and 2002
	American shad	summer/fall, 2001 and 2002
	other species	as availability and time permit

g. Feasibility

This proposal requests next-phase funding for continuation and expansion of a successful, ongoing research program that addresses uncertainties associated with a major CALFED-identified stressor, water diversions. The Fish Treadmill Project is the most appropriate and comprehensive approach to address questions relating to specific aspects of fish screen design, flow criteria, and operation. This cooperative project, with the versatile, fully operational Fish Treadmill apparatus, highly qualified staff, and associated fish collection and maintenance facilities, is the only large scale fish screen research program capable of testing delicate, high priority native species like delta smelt under wide ranges of realistic, controlled flow and environmental conditions. The project has already produced detailed quantitative data that will be used to develop fish screen flow and operational criteria that protect native priority fishes of the Sacramento-San Joaquin watershed. There are no alternatives presently available or in place to meet the stated objectives within CALFED's short time frame or to provide needed information for the development and/or evaluation of other CALFED sponsored programs like the Tracy Fish Test Facility and the Hood-Mokelumne Connection.

The targeted research outlined in this proposal is feasible, independent of the outcomes of other projects, and (generally) independent of natural conditions (e.g., weather, although inadequate supplies of wild or hatchery-reared test fishes could affect the rate of research). The

Fish Treadmill apparatus has proved to be both versatile and durable with few technical or mechanical failures during the past 2.5 years of operation. The project will occur in a laboratory setting and requires no CEQA, NEPA, or other environmental compliance documents. Permits required to continue this project (e.g., DFG/IEP collection permit, water discharge permits, and UCD animal care protocols) are approved or have been submitted. Detailed Biological Monitoring/Research and Quality Assurance plans have been approved. No zoning regulations, planning ordinances or other constraints that could impact the schedule and implementability of the project are known.

D. APPLICABILITY TO CALFED ERP GOALS AND IMPLEMENTATION

PLAN AND CVPIA PRIORITIES (2 pages, and see Appendix 1 for present project status)

1. Relationship to ERP and CVPIA Priorities and Other Ecosystem Restoration Projects

The Fish Treadmill project addresses a major stressor, water diversions, that has uncertain impacts on fishes in the Sacramento-San Joaquin watershed. The project is specifically designed to produce the scientific information necessary for CALFED to reduce the adverse impacts of the stressor by installation of protective fish screens designed based on improved understanding of the magnitude and mechanisms underlying near-field water diversion effects on fishes. Results of this project will provide benefit to 11 of the 14 Ecological Management Zones defined by CALFED (most located in the Bay/Delta and mainstem rivers) and to virtually all of the highest priority fish species (delta smelt, splittail, chinook salmon, steelhead, green sturgeon). For example, in the Sacramento-San Joaquin Delta Ecological Management Zone, reduction of entrainment and impingement losses of fish at water diversions is identified as a target, with replacement/upgrades of the SWP, CVP, and PG&E screens identified as specific programmatic actions (ERP, Vol. 2, p. 110). For protection of fishes like delta smelt, splittail and chinook salmon, results of the Fish Treadmill project are essential to develop the design and operational criteria for these new and/or upgraded fish screens. In addition, Fish Treadmill results will be useful for the development of the Tracy Fish Test Facility (TFTF) and as part of the recently initiated technical evaluations for the proposed Hood-Mokelumne Connection.

Support for continuation of the Fish Treadmill project and its scientific evaluation of fish performance and behavior near fish screens is identified by CALFED as an activity that will help it achieve its strategic objective of reducing entrainment of fish at water diversions in order to increase fish survival and population abundances to levels that contribute to the overall health of the Delta and other beneficial uses of land and water (ERP, Vol. 1, p. 428-429). By developing the data and technology to reduce water diversion impacts, the project has links to other ecosystem elements and CALFED goals, including:

- **native species recovery and conservation**, with an emphasis on listed species like delta smelt, splittail, chinook salmon, and steelhead trout (CALFED Goal 1);
- **improving recreational and commercial fisheries** (e.g., chinook salmon, steelhead trout) (CALFED Goal 3);
- **successful implementation of the CVPIA** (e.g., fish doubling goals); and
- **successful implementation of recovery measures for listed species (state and federal ESA).**

The Fish Treadmill project also addresses at least two other Stage 1 expectations (ERP, Vol. 1, p. 428-429), continued research on fish screen and related facilities design, and coordinating research and testing various screen programs. In addition, the Proposed Fish Facility Technology Development Interagency Technical Forum (members include representatives from

CALFED, DWR, DFG, USBR, NMFS, and USFWS), in discussion of new technology requirements for Delta fish facilities, agreed that technology development should include cooperative research with UCD and the Fish Treadmill project, especially for refined programs for studying criteria with sensitive species such as delta smelt.

2. System-wide Ecosystem Benefits

Results of the Fish Treadmill project, when applied to improve fish screen design and operation and thus reduce the adverse impacts of water diversions, will have broad, system-wide ecosystem benefits, affecting

- **habitats** (e.g., both Delta and upstream habitats, including tidal perennial aquatic habitat, instream aquatic habitat, and shaded riverine habitat);
- **species**, with an emphasis on priority, listed native species like delta smelt, steelhead, splittail, chinook salmon, and sturgeon; and
- **ecological processes** (e.g., reducing losses of juvenile fishes at water diversions will improve Bay/Delta and upstream food webs).

Fish Treadmill project results obtained for listed native fishes, species that can affect operation of large water diversions (e.g., by take limits), have direct and timely application for development, design, and operation of several large fish facilities integral to non-ecosystem related CALFED objectives like **water supply reliability**. These include the improvements to the SWP and CVP fish screens, proposed fish screens at upstream diversion(s) for off-stream storage, and the Hood-Mokelumne Connection.

3. Request for Next-Phase Funding

The Fish Treadmill project is an ongoing targeted research program, currently supported by CALFED (Project # 99-N02, Fish Treadmill-developed Fish Screen Criteria for Native Sacramento-San Joaquin Watershed Fishes, J. J. Cech, Jr., Principal Investigator) and previously supported by DWR and USBR (contracts B-58719 and B-80898, 1994-1998, for Fish Treadmill final design, construction, and preliminary biological studies; and B-81622, 1998-2000, for continuation of the biological studies; results of these early Fish Treadmill studies are reported in Velagic et al., 1998, Chen et al., 1998; Swanson et al., 1998a, 1999; and Hayes et al., 2000). The project builds upon work by DFG using a smaller circular flume with a fish screen (Kano 1982) and upon which present fish screen flow criteria are based. The design of the biological studies using the Fish Treadmill was also based on results of previous work by the UCD Fish Physiology Group on environmental biology and behavior of native Delta and upstream fishes (e.g., delta smelt, Swanson and Cech, 1995, Swanson et al. 1996, 1998a and c; splittail, Young and Cech, 1996; chinook salmon, Young et al. 1998). The Fish Treadmill project directly complements and expands upon ongoing fish screen studies at operational water diversions (e.g., GCID, and Red Bluff Diversion Dam, RBDD) and project results will be incorporated into design and operation of the Tracy Fish Test Facility and new facilities at the SWP, SVP, and Hood Mokelumne Connection.

The Fish Treadmill biological studies were originally designed with a three-year study schedule and an emphasis on native Delta fishes (delta smelt, splittail, chinook salmon) and American shad (to produce data more directly comparable to Kano, 1982). By the end of the present contract (CALFED project # 99-N02), three years of biological studies will have been completed. During this period, concern for native Delta fishes has remained high and, because of proposed large upstream fish screen facilities (e.g., off-stream storage, Sacramento river) and

upgrades to existing facilities (e.g., GCID), interest for threatened upstream species like steelhead and sturgeon has increased. Therefore, the focus of the Fish Treadmill project has been shifted to include studies with these (and other) species. In addition, discussions with several fish facilities development and review teams have supported the use of the Fish Treadmill for evaluation of other fish screen issues, such as effects of debris loading on fish screen function and fish performance.

E. QUALIFICATIONS

A. Organization of Staff

The project will be under the direction and supervision of the principal investigator, Joseph J. Cech, Jr., Professor in the Department of Wildlife, Fish, and Conservation Biology, University of California, Davis (Biological Studies, Task 2) and the co-investigator, Dr. M. L. Kavvas, Department of Civil and Environmental Engineering, University of California, Davis (Fish Treadmill Operation, Task 1). G. Aasen (DFG) will provide additional management and support for fish collection (Task 3). Day to day project management, implementation, data analysis, interpretation and report writing will be provided by two post-doctoral researchers, co-investigators Drs. Paciencia S. Young (Task 2) and Z. Q. Chen (Task 1). Additional assistance with fish collection, fish care, fish management, experiment implementation, data collection, data entry, preliminary data analysis, and data quality control and assurance will be provided by full and part-time post-graduate researchers, student research assistants, and DFG researchers and scientific aides.

B. Collaborating Scientists

Dr. Joseph J. Cech, Jr. has been a professor at UCD since 1975 and was Chair of the Department of Wildlife, Fish, and Conservation Biology from 1992-1997. He has published more than 80 peer-reviewed articles in the fields of physiology and physiological ecology of fishes, and has won numerous awards, honors and grants. He has completed eight contracts with state agencies for studies of the physiological ecology of fishes of the Sacramento-San Joaquin system. He is presently Principal Investigator on the Fish Treadmill Project. Relevant publications include:

Cech, J. J., Jr., Mitchell, S. J., Castleberry, D. T., and McEnroe, M. (1990) Distribution of California stream fishes: influence of environmental temperature and hypoxia. *Env. Biol. Fish.* 29:95-105.

Cech, J. J., Jr., Bartholow, S. D., Young, P. S., and Hopkins, T. E. (1996) Striped bass exercise and handling stress in fresh water: physiological responses to recovery environment. *Trans. Am. Fish. Soc.* 125:308-320.

Moyle, P. B. and Cech, J. J., Jr. (2000) *Fishes: and introduction to ichthyology*. 4th edition, Prentice Hall, Englewood Cliffs, New Jersey.

Dr. M. Levent Kavvas has been a professor in the Department of Civil and Environmental Engineering since 1985 and Director of the UCD Hydraulics Laboratory since 1991. He is the author of more than 75 journal and proceedings publications in the areas of hydraulic and hydrologic engineering. His areas of specialization include: physical hydraulic modeling of environmental fluid flows, pollutant and sediment transport, and modeling of hydrologic processes.

such as overland flow, erosion, and infiltration. He is presently co-investigator on the Fish Treadmill project. A recent relevant publications is:

Velagic, E., M. L. Kavvas, W. Summer, and others (1996) Fish Screen test apparatus with variable two-vector flow conditions: hydraulic model. Final Report for California Department of Water Resources contract B-58719.

Dr. Paciencia S. Young received her doctoral training and is presently a post-doctoral researcher in Dr. Cech's laboratory. She is an expert in the areas of stress and exercise physiology of fishes and has spent the past five years studying the environmental tolerances, swimming performance, and behavior of Delta fishes, with an emphasis on splittail and delta smelt. She was the managing researcher on three successfully completed state contracts and is presently one of the managing biologists on the Fish Treadmill project. Recent relevant publications include:

Young, P. S., C. Swanson, and J. J. Cech, Jr. (1998) Performance, behavior, and physiological responses of Delta fishes in two-vector flows in a fish treadmill. Part 2. Illumination and photophase effects on swimming performance and behavior of Delta fishes. Final Report, California Department of Water Resources. 57 pp.

Young, P. S. and J. J. Cech, Jr. (1996) Environmental tolerances and requirements of splittail. Trans. Am. Fish. Soc. 125:664-678.

Young, P. S. and J. J. Cech, Jr. (1995) Environmental requirements and tolerances of Sacramento splittail, *Pogonichthys macrolepidotus* (Ayres). Final Report to the Interagency Ecological Studies Program for the San Francisco Bay/Delta. 56 pp.

Young, P. S. and J. J. Cech, Jr. (1993) Effects of exercise conditioning on stress responses and recovery in cultured and wild young-of-the-year striped bass (*Morone saxatilis*). Can. J. Fish. Aquat. Sci. 50:2094-2099.

Dr. Z. Q. Chen is a Research Engineer and the manager of the UCD Hydraulics Laboratory. He has worked on various hydraulic modeling studies for more than ten years, and currently is the lead hydraulic engineer for the Fish Treadmill Project. Dr. Chen specializes in physical hydraulic models, hydraulic engineering, and hydrological modeling. A recent relevant publication is:

Chen, Z. Q., E. Velagic, A. Karakas, E. Dogrul, H. Bandeh, W. Summer, and M. L. Kavvas (1998) Performance, behavior, and physiological responses of Delta fishes in two-vector flows in a fish treadmill. Part 1. Hydraulics Studies. Final Report, California Department of Water Resources. 42 pp.

Geir Aasen is a biologist with the Bay/Delta division of DFG and has been working with the Fish Treadmill project since January 2000. He will serve as primary Interagency liaison for fish collection, and assist the UCD staff in experimental design, implementation, and data analysis, and data quality control and assurance for the Fish Treadmill experiments.

F. COST

1. Budget

CALFED next-phase funding is requested for a two-year period to support continued operation of the Fish Treadmill (Task 1, UC Davis Hydraulics Laboratory), implementation of the biological studies (Task 2, UC Davis Fish Physiology Group), and DFG assistance for fish collection and participation in the experiments (Task 3), and project management (Task 4, UC Davis Fish Physiology Group).

Cost of the project depends on funding source: \$1,786,605 if funded through a State agency and \$2,271,637 if funded through a federal agency. Details of the budget are described in Tables 9 and 10 (MS Excel file name: treadmill.calfed2000.xls, worksheet 1=budget with state overhead rates, worksheet 2=budget with federal overhead rates) and in the Budget Justification below.

2. Budget Justification

Task 1. Fish Treadmill Operation, Maintenance, and Calibration: The success of the project depends heavily on the proper function of the experimental apparatus, the Fish Treadmill. The UC Davis Hydraulics Engineering Group is responsible for this activity that includes: operation of the Fish Treadmill during all experiments; maintenance and repair of the Fish Treadmill; regular change of underground sump water; temperature control of sump water; maintenance and oversight of sump water quality (e.g. dissolved oxygen, ammonia, pH, alkalinity, and hardness); regular calibration of approach and sweeping flow combinations in the Fish Treadmill swimming channel; and report writing and presentation of results. Operation of the Fish Treadmill during experiments demands simultaneous and continuous adjustments by two engineers of incoming flow and discharge, water depth in the swimming channel, and the speed of the rotating outer screen. At least four part-time engineers are needed to ensure normal operation of the Fish Treadmill for two shifts each day. Additionally, they are also responsible for monitoring water quality before, during, and after the experiments. Two part-time mechanical technicians are needed for regular maintenance and repair of the Fish Treadmill.

Funds are requested for personnel (salaries, benefits and student fee remissions), expendable supplies, general liability, and overhead (detailed in Table 6, below).

Table 6. Budget details for Task 1, UC Davis Hydraulics Laboratory.

Position	Pay Rate	Expected Time Commitment	Benefits/Salary
M. L. Kavvas	\$149,651	12.5% (1.5 months, summer)	9.2%
Senior Res. Engr.	\$46,809	100%	24.5%
PGRE 1	\$27,287	75%	4.3%
PGRE 3 (2)	\$29,768	75%	4.3%
PGRE 4	\$31,024	75%	18.5%
Supplies (water quality tests, repairs, maintenance, publications)	\$12,500/year		
General liability	\$1,400/year		
Overhead	see Tables 9 and 10 for state and federal University overhead rates		

Task 2. Biological Experiments: Biological studies using the Fish Treadmill are the responsibility of the UC Davis Fish Physiology Group. Personnel from DFG also participate in some aspects of this task. This task includes: fish care and management; maintenance of fish and holding tank water quality; preparation for and implementation of experiments; post-experiment fish health and water quality; data entry; data analyses; interpretation of results; report writing; and presentation of results. Each experiment requires three to five researchers (depending on experimental flow and time of day, i.e., day vs night) for preparation, implementation, and immediate post-experiment activities. Each experiment also requires approximately four hours of motion analyses for fish behavior measurements, three hours of data entry and data quality assurance record keeping.

Funds are requested for personnel (salary, benefits, and student fee remissions), expendable supplies (fish care materials, office supplies, laboratory supplies, video tapes, chemicals, bottled gases, repairs and maintenance, reports, publications and presentation costs, discharge permit and required water quality analyses, materials for debris loading experiments, etc.), UC Davis Aquatic Center fish holding tank usage fees, travel (fish collection and transport, meeting and presentations). The continuing project also requires three equipment items: an updated motion analysis system for analyses of fish behavior, a replacement part for the fish holding facility chiller, and an electric power failure alarm for the fish holding facilities at the Hydraulics Laboratory.

Table 7. Budget details for Task 2, UC Davis Fish Physiology Group.

Position	Pay Rate	Expected Time Commitment	Benefits/Salary
J. J. Cech, Jr.	\$0 (see Cost Sharing)	10%	N/A
PGR VI	\$50,400	100%	31.3%
PGR V	\$39,000	100%	28.2%
PGR II (4)	\$34,000	100%	26.5%
Graduate Res. Asst	\$20,000	75%	1.75%
Student Res. Asst. (6)	\$3,250	25%	1.75%
Supplies	\$29,000/year		
Equipment (Year 1 only)	\$45,200		
Travel	\$6,000/year		
Overhead	see Tables 9 and 10 for state and federal University overhead rates		

Task 3: Fish Collection: Fish field collection is primarily the responsibility of the DFG, in collaboration with the UC Davis Fish Physiology Group. This task includes: determining collection site locations based on DFG field monitoring data; scheduling collection expeditions; operation and maintenance of fishing boat and collection gear; and transport of collected fish to the UC Davis fish holding facilities. Each fish collection expedition for delta smelt involves at least four people to operate the boat, check Delta water condition, set and pull the purse seine, collect the fish, and transport the fish to UC Davis. Each fish collection takes approximately two

hours boat and net preparation, two hours actual fish collection, two hours post-collection clean-up, and two hours post-transport fish care. Note that, in addition to this task, DFG personnel also participate in Task 2, biological studies using the Fish Treadmill.

Funds are requested to subcontract with DFG for these services, which include personnel (salaries and benefits), supplies, and operational expenses, travel, and DFG agency overhead (@ 17.3% of DFG total direct costs).

Table 8. Budget details for Task 3, DFG.

Position	Pay Rate	Expected Time Commitment	Benefits/Salary
G. Aasen	\$52,500	20%	32%
FW Asst.	\$30,250	100%	32%
Scientific Aides (4)	\$14,545/9 months	100%	0%
Supplies	\$3,500/year		
Operational Expenses	\$3,880/year		
Travel	\$21,090/year		
Overhead (DFG overhead)	\$24,673 (17.3% of total direct costs)		
Overhead (University overhead)	see Tables 9 and 10 for University overhead rates		

Project Management: Project management (estimated at a 10% time commitment/group) will be conducted by the Principal Investigator, J. J. Cech, Jr. (UC Davis, Biological Studies, Task 2), post-doctoral researcher P. S. Young (Biological Studies), and co-investigators M. L. Kavvas (UC Davis, Fish Treadmill Operation) and G. Aasen (DFG, Interagency liaison and Fish Collection). Project management includes oversight of work in progress, validation of costs, preparation of quarterly reports, and responses to specific questions associated with project oversight.

3. Cost Sharing

From its inception in 1994 to February 16, 2000 when CALFED support began, the Fish Treadmill project, including design, construction, modification, and calibration of the apparatus, upgrades to the UC Davis fish holding facilities, fish field collection, and all aspects of the hydraulic and biological studies conducted using the apparatus, has been funded by DWR and USBR. DWR also provided funding to DFG to offset their costs for participation in the project (i.e., assistance with fish field collection and experimental data collection). For the period for which next-phase funding is requested from CALFED in this proposal, UC Davis will contribute a percentage of the Principal Investigator's salary (J. J. Cech, Jr., 10%) plus benefits for a total of \$12,739.

Table 9. Budget for two years of Fish Treadmill project with 10% (state) overhead rate.

Year	Task	Direct Labor Hours	Subject to Overhead						Exempt from Overhead			Total Cost
			Salary	Benefits	Travel	Supplies & Expendables	Agency Overhead (@17.3% of total direct costs)	Overhead (10% for all tasks)	Equipment	Remission	Graduate Student Fee	
Year 1	Task 1	8250	\$201,249	\$31,903	\$0	\$13,900	\$0	\$24,705	\$0	\$14,895	\$0	\$286,652
	Task 2	16700	\$255,960	\$60,775	\$6,000	\$44,000	\$0	\$36,674	\$30,200	\$4,500	\$0	\$438,109
	Task 3	8400	\$98,930	\$15,220	\$21,090	\$7,380	\$24,673	\$2,500	\$0	\$0	\$0	\$169,793
	Task 4	400	\$8,940	\$2,675	\$0	\$0	\$0	\$1,162	\$0	\$0	\$0	\$12,777
Total Cost Year 1			\$565,079	\$110,573	\$27,090	\$65,280	\$24,673	\$65,041	\$30,200	\$19,395	\$0	\$907,331
Year 2	Task 1	8250	\$211,310	\$34,114	\$0	\$13,900	\$0	\$25,932	\$0	\$15,639	\$0	\$300,895
	Task 2	16700	\$255,960	\$60,775	\$10,000	\$29,000	\$0	\$35,574	\$0	\$4,500	\$0	\$395,809
	Task 3	8400	\$98,930	\$15,220	\$21,090	\$7,380	\$24,673	\$2,500	\$0	\$0	\$0	\$169,793
	Task 4	400	\$8,940	\$2,675	\$0	\$0	\$0	\$1,162	\$0	\$0	\$0	\$12,777
Total Cost Year 2			\$575,140	\$112,784	\$31,090	\$50,280	\$24,673	\$65,168	\$0	\$20,139	\$0	\$879,274
Total Project Cost			\$1,140,219	\$223,357	\$58,180	\$115,560	\$49,346	\$130,209	\$30,200	\$39,534	\$0	\$1,786,605

Table 10. Budget for two years of Fish Treadmill project with 46.5-48% (federal) overhead rate.

Year	Task	Direct Labor Hours	Subject to Overhead						Exempt from Overhead			Total Cost
			Salary	Benefits	Travel	Supplies & Expendables	Agency Overhead (@17.3% for total direct costs)	Overhead (@46.5% for Year 1 and @48% for Year 2)	Equipment	Remission	Graduate Student Fee	
Year 1	Task 1	8250	\$201,249	\$31,903	\$0	\$13,900	\$0	\$114,879	\$0	\$14,895	\$0	\$376,826
	Task 2	16700	\$255,960	\$60,775	\$6,000	\$44,000	\$0	\$170,532	\$30,200	\$4,500	\$0	\$571,967
	Task 3	8400	\$98,930	\$15,220	\$21,090	\$7,380	\$24,673	\$11,625	\$0	\$0	\$0	\$178,918
	Task 4	400	\$8,940	\$2,675	\$0	\$0	\$0	\$5,401	\$0	\$0	\$0	\$17,016
Total Cost Year 1			\$565,079	\$110,573	\$27,090	\$65,280	\$24,673	\$302,437	\$30,200	\$19,395	\$0	\$1,144,727
Year 2	Task 1	8250	\$211,310	\$34,114	\$0	\$13,900	\$0	\$124,476	\$0	\$15,639	\$0	\$399,439
	Task 2	16700	\$255,960	\$60,775	\$10,000	\$29,000	\$0	\$170,753	\$0	\$4,500	\$0	\$530,988
	Task 3	8400	\$98,930	\$15,220	\$21,090	\$7,380	\$24,673	\$12,000	\$0	\$0	\$0	\$179,293
	Task 4	400	\$8,940	\$2,675	\$0	\$0	\$0	\$5,575	\$0	\$0	\$0	\$17,190
Total Cost Year 2			\$575,140	\$112,784	\$31,090	\$50,280	\$24,673	\$312,804	\$0	\$20,139	\$0	\$1,126,910
Total Project Cost			\$1,140,219	\$223,357	\$58,180	\$115,560	\$49,346	\$615,241	\$30,200	\$39,534	\$0	\$2,271,637

G. LOCAL INVOLVEMENT

The Fish Treadmill project is an ongoing University-based, laboratory program. All required notifications and approvals (e.g., water discharge permit) to UC Davis, local governments, landowners, environmental groups, and other interested organizations are in place. Public outreach to interested parties (including academics, state and federal agency personnel, local and state media, and the general public) is accomplished through scheduled bi-annual meetings, IEP Newsletter articles, journal articles in the scientific and technical press, and related UC Davis press releases.

H. COMPLIANCE WITH STANDARD TERMS AND CONDITIONS

The University of California, Davis, and the California Department of Fish and Game are public organizations of the State of California. Both organizations comply with the standard terms and conditions of non-discrimination and non-collusion. There are no conflicts of interest.

I. LITERATURE CITED

- Chen, Z. Q., E. Velagic, A. Karakas, E. Dogrul, H. Bandeh, W. Summer, and M. L. Kavvas (1998) Performance, behavior, and physiological responses of Delta fishes in two-vector flows in a fish treadmill. Part 1. Hydraulics Studies. Final Report, California Department of Water Resources. 42 pp.
- Hayes, D. E., S. D. Mayr, M. L. Kavvas, Z. Q. Chen, E. Velagic, A. Karakas, H. Bandeh, E. C. Dogrul, J. J. Cech, Jr., C. Swanson, and P. S. Young. (2000) Fish screen velocity criteria development using a screened, circular swimming channel. In *Advances in Fish Passage Technology*, (M. Odeh, ed.). American Fisheries Society: Bethesda, MD. (in press.)
- Kano, R. M. (1982) Responses of juvenile chinook salmon, *Oncorhynchus tshawytscha*, and American shad, *Alosa sapidissima*, to long term exposure to two-vector velocity flows. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary, Technical Report 4. 20 pp.
- Swanson, C. and J. J. Cech, Jr. (1995) Environmental tolerances and requirements of the delta smelt, *Hypomesus transpacificus*. Final Report, California Department of Water Resources. 71 pp.
- Swanson, C., R. Mager, S. I. Doroshov, and J. J. Cech, Jr. (1996) Use of salts, anesthetics, and polymers to minimize handling and transport mortality in delta smelt. Transactions of the American Fisheries Society 125:326-329.
- Swanson, C., P. S. Young, and J. J. Cech, Jr. (1998a) Performance, behavior, and physiological responses of Delta fishes in two-vector flows in a fish treadmill. Part 3. Biological studies using the fish treadmill. Final Report, California Department of Water Resources. 59 pp.
- Swanson, C., P. S. Young, and J. J. Cech, Jr. (1998b) Performance, behavior, and physiological responses of Delta fishes in two-vector flows in a fish treadmill. Part 4. Quality assurance project plan. Final Report, California Department of Water Resources. 160 pp.
- Swanson, C., P. S. Young, and J. J. Cech, Jr. (1998c) Swimming performance of delta smelt: maximum performance, and behavioral and kinematic limitations on swimming at submaximal velocities. Journal of Experimental Biology. 201:333-345

- Swanson, C., T. Reid, P. S. Young, and J. J. Cech, Jr. (2000) Comparative environmental tolerances of threatened delta smelt (*Hypomesus transpacificus*) and introduced wakasagi (*H. nipponensis*) in an altered California estuary. (in press)
- Velagic, E., Z. Q. Chen, A. Karakas, E. Dogrul, H. Bandeh, W. Summer, M. L. Kavvas, C. Swanson, P. S. Young, and J. J. Cech, Jr. (1998) Performance, behavior and physiology of Delta fishes in variable two-vector flows. Progress Report, California Department of Water Resources, Contract B 80898. 93 pp.
- Young, P. S. and J. J. Cech, Jr. (1996) Environmental tolerances and requirements of splittail. Trans. Am. Fish Soc. 125:664-678.
- Young, P. S., C. Swanson, and J. J. Cech, Jr. (1998) Performance, behavior, and physiological responses of Delta fishes in two-vector flows in a fish treadmill. Part 2. Illumination and photophase effects on swimming performance and behavior of Delta fishes. Final Report, California Department of Water Resources. 57 pp.

J. THRESHOLD REQUIREMENTS

UC Davis is a State-assisted public research and educational institution. California Department of Fish and Game is a Constitutionally mandated agency of the State of California. (Non-Profit, exempt under status 501(c)(3) of the IRS code of 1954 under Type of organization and Tax Status). Tax Identification Number for UC Davis is 94-603-6494. Also see attached documents.

Appendix I

CURRENT PROJECT STATUS SUMMARY (CALFED #99-N02)

The Fish Treadmill project is a cooperative, multi-agency, targeted research program that addresses the uncertain impacts of water diversions and fish screens on priority fish species (e.g., delta smelt, splittail, chinook salmon, steelhead). The project, begun in 1994 with funding and/or support from DWR, DFG, NMFS and USBR, was intended to build upon the pioneering work by DFG (Kano, 1982) by providing comprehensive and rigorous data on fish-fish screen interactions for newly listed priority species like delta smelt. Fish Treadmill project results will be applied to evaluate and improve aspects of fish protective facility design and operation at the State Water Project (SWP), Central Valley Project (CVP, including the Tracy Fish Test Facility, TFTF), and other existing and proposed fish screen facilities (e.g., Red Bluff Diversion Dam, Glenn-Colusa Irrigation District, Hood-Mokelumne Connection).

Research with the Fish Treadmill focuses on near-field effects (i.e., near-screen effects), evaluating fish screen and flow impacts on fish survival, injury, stress, and passage and correlating them with screen design and operational criteria (i.e., approach and sweeping velocity), species and life history stage, and environmental conditions (e.g., temperature, day vs night). The conceptual model (Figure 1), hypotheses, and experimental design used in the studies were developed with input and collaboration from participating agencies, outside consultants (e.g., Ken Bates, Washington State Department of Fisheries, and Ned Taft, Alden Research Laboratories), and other interested parties (e.g., Metropolitan Water District).

Biological studies using the Fish Treadmill began in late 1997 with experiments with splittail and delta smelt. Since then, more than 450 experiments, with delta smelt, splittail, chinook salmon, steelhead, green sturgeon, and American shad, have been completed. CALFED support of Fish Treadmill research activities began on February 16, 2000. Table 11 (following page) outlines the present status of the studies (through April 30, 2000) and the predicted status at the end of the present CALFED-supported period (March 31, 2001). Results of these studies have been presented in several technical reports (Velagic et al., 1998, Chen et al., 1998; Swanson et al., 1998a, 1999; and Hayes et al., 2000), IEP Newsletter articles, and as oral and poster presentations at scientific meetings (e.g., American Fisheries Society meetings).

During the CALFED-supported period, Fish Treadmill operation activities included controlling, monitoring, and adjusting (as necessary) of water flow conditions (i.e., approach and sweeping velocities, and water depth), water temperature, and other water quality variables (e.g., dissolved oxygen concentration, pH, and total ammonia). A total of 33 biological experiments were conducted during the first quarter and, for all, these variables were within acceptable ranges (as defined by the Biological Monitoring/Research Plan, BM/RP). Three scheduled experiments were canceled because of unacceptable Fish Treadmill water temperatures (2 experiments) or a power failure (1 experiment). Fish Treadmill maintenance performed during this quarter included flushing and replacement of the Fish Treadmill water supply stored in the underground sump (required to maintain acceptable water quality), replacement of damaged supporting wheels of the outer rotating screen, and repair of the rotating drum on the outer screen. The SonTek acoustic Doppler acoustic velocimeter was calibrated and the discharge readings of the ultrasonic water flow meter were verified using the outer circular weir inside the Fish Treadmill tank. As required by the California Regional Water Resource Control Board (CRWRCB), the quantity and quality of the water released from the Hydraulics Laboratory fish holding tanks was monitored and

reported to CRWRCB (monthly). In addition to these activities, Hydraulics Laboratory engineers provided engineering services to the biologists, modifying and replacing electrical wiring of view plates used in biological experiments, advising on the fish releasing container design, and designing and constructing new attachment/supports for night vision goggles used in nighttime experiments.

During this quarter, biological experiments were conducted with delta smelt (6-8 cm SL: 7 experiments), chinook salmon (6-8 cm SL: 5 experiments, 4-6 cm SL: 19 experiments), and steelhead, (< 4 cm SL: 2 experiments). All pre- and post-experiment conditions and experimental protocols were acceptable as defined by the BM/RP. Experiments using 6-8 cm SL fish were also used for physiological stress response measurements. Plasma samples from some of these fish were frozen for later analysis. Computer-assisted motion analyses (using Peak Performance Technologies, Inc. motion analysis system) of video tape records from experiments conducted earlier this year was completed for 21 experiments with delta smelt and splittail. Data entry and analyses continued for experiments conducted earlier this year and during the previous year. Screen contact rate descriptive statistics were generated for 110 experiments with chinook salmon, and 180 experiments with splittail. All health assessment data on previous experiments with delta smelt, chinook salmon and splittail (total of 327 experiments) were updated to included new health assessment indices.

During this quarter, we collected 500 chinook salmon (parr) from Nimbus Hatchery and 1,000 steelhead (fry) from Coleman Hatchery. As required by the BM/RP, these fishes were subjected to prophylactic treatments for 10 days and held for another 10 days before being used for biological experiments.

Table 11. Status of Fish Treadmill biological studies (Type 1 experiments only, effects of flow and environmental conditions), October 1997-April 2000.

Species	# of Experiments	% Complete	% Complete by March 2001 (estimated)
Delta smelt	102	57	90
Splittail	178	98	100
Chinook salmon	140	69	100
Steelhead	17	28	50
Green sturgeon	7	<10	30
American shad	7	<10	50

Appendix II

**FISH TREADMILL-DEVELOPED FISH SCREEN
CRITERIA FOR NATIVE SACRAMENTO-SAN
JOAQUIN WATERSHED FISHES**

CALFED Project #: 99-N02

Biological Monitoring/Research Plan

based on the Quality Assurance Project Plan prepared by

Christina Swanson

Paciencia S. Young

Joseph J. Cech, Jr.

**Department of Wildlife, Fish, and Conservation Biology
University of California, Davis**

Robert Fujimura

Bay-Delta Division

California Department of Fish and Game

Ted Frink

Environmental Services Office

California Department of Water Resources

for

Department of Water Resources and the Interagency Ecological Program, 1998

I. Introduction and Background

This Biological Monitoring/Research Plan (BM/RP) is based the Quality Assurance Project Plan (QAPP, Swanson et al. 1998) developed for Interagency Ecological Program-supported studies using the Fish Treadmill (Performance, Behavior and Physiology of Delta Fishes in Two-Vector Flows in a Fish Treadmill, M. L. Kavvas and J. J. Cech, Jr., principal investigators). The objective of these documents is to describe and define objectives, experimental design, methods, personnel training requirements, data quality objectives and acceptability criteria, data reduction and analyses methods, and standard operating procedures for all aspects of the biological studies using the Fish Treadmill.

A. Project History

The fisheries resources of the Sacramento-San Joaquin Delta system have been recognized as valuable state resources for several decades. A number of fish species, including the endangered winter-run chinook salmon and threatened delta smelt have been jeopardized by the increased water demand by agriculture, domestic, municipal, industrial, and recreational users of California (Kawasaki and Raquel 1995). State law provides the California Department of Fish and Game (CDFG) the authority for installation of fish screens on water diversions to reduce fish losses. Kano (1982) described pioneering efforts to examine survival of fishes exposed to controlled flow regimes and fish screens like those at water diversions. However, many technical, biological, and environmental problems related to diversion design and operation in the Delta have not been resolved. To address these questions, the Fish Facilities Technical Committee of the Interagency Ecological Program proposed the Fish Treadmill Project in order to determine:

- how Delta fish species of various sizes and swimming abilities might behave if subjected to a screened barrier adjacent to the river; and
- the suitable approach velocity and screen exposure duration for various fish species.

In 1994, the Hydraulics Laboratory of the University of California, Davis (UCD), headed by M. L. Kavvas, was contracted to design and construct a small-scale fish treadmill model as well as a full-scale fish treadmill prototype. The apparatus was designed to provide controlled, relatively uniform flow regimes, at levels similar to those currently required for screened water diversions, in a relatively large volume, annular flume or swimming chamber in which fish could be confined and their responses to the flow and screen observed and quantified. Upon completion of the Fish Treadmill prototype, the UCD Fish Physiology Group, headed by J. J. Cech, Jr., began biological studies to evaluate the performance and behavior of selected Delta fishes in the apparatus under a range of biological and environmental conditions. This Quality Assurance Project Plan (QAPP), developed during the first year of biological testing using the Fish Treadmill, describes the activities associated with the biological studies using the Fish Treadmill with the understanding that the UCD Hydraulics Laboratory will operate and maintain the Fish Treadmill, provide detailed flow velocity and vector maps of the swimming channel within the Fish Treadmill for each of the experimental flow regimes to the Fish Physiology Group, and maintain stable flow regimes and water quality throughout the experimental periods at levels defined as acceptable in this QAPP.

B. Project Objectives

Biological studies will be conducted to evaluate Delta fishes' swimming performance, and behavioral and physiological responses to exposure to a two-vector flow field with a screened barrier.

Objective 1: Evaluate and quantify the performance (i.e., survival, impingement) of selected Delta fishes exposed to two-vector flow regimes and environmental conditions (e.g., temperature, light level) similar to those that occur near fish screens in the Delta and local riverine systems.

Objective 2: Evaluate and quantify the behavior (e.g., swimming velocities, orientation to screen and water flows, distance traveled, etc.) of Delta fishes exposed to two-vector flow regimes and environmental conditions similar to those that occur near fish screens in the selected Delta and local riverine systems.

Objective 3: Evaluate and quantify the physiological stress responses of Delta fishes exposed to two-vector flow regimes and environmental conditions similar to those that occur near fish screens in the selected Delta and local riverine systems.

Objective 4: Compare the performance, behavior, and physiological responses of the tested fish species to determine differential vulnerability to entrainment and impingement at fish screens.

Objective 5: Compare results from these studies with those of Kano (1982).

Objective 6: Compare results from these studies with present fish screen and flow criteria specified for the Delta and local river systems (NMFS, 1997; CDFG, 1997; USFWS, 1994).

Objective 7: In collaboration with state and federal agency personnel, suggest refinements for present fish screen flow and operational criteria for each of the tested species.

C. Determination of Success

The project is successful when complete, statistically testable data sets have been generated, analyzed, interpreted, and documented in a Final Report to the funding agency.

D. Use and Users of Information

Results of these studies will be provided to CALFED as quarterly and final reports for their use in evaluating and revising present fish screen flow and operational criteria to better protect fishes in the Delta and riverine systems and reduce losses due to entrainment and impingement. Results will also be reported in IEP Newsletter articles, presented at interagency workshops and scientific meetings, and will be submitted for publication in peer-reviewed scientific and management journals for wide dissemination.

II. Project Organization

A. Responsibilities

Task 1: Fish Treadmill Operation, Maintenance and Calibration

Prof. M. Levent Kavvas,

Department of Civil and Environmental Engineering, University of California, Davis, CA 95616,
(530) 752-2518, mlkavvas@ucdavis.edu.

Supervise operation of the design, construction, testing, calibration, and operation of the Fish Treadmill apparatus; ensure the completion of high-quality projects within established budgets and time schedules; provide guidance and technical advice to those assigned to projects by evaluating performance, implement corrective actions and provide professional development to staff; review preparation of project deliverables; interact with technical reviewers and agencies to assure technical quality requirements are met in accordance with contract specifications.

Task 2: Biological Studies

Prof. Joseph J. Cech, Jr.

Department of Wildlife, Fish, and Conservation Biology, University of California, Davis, CA 95616, (530) 752-3103, jjcech@ucdavis.edu

Supervise and participate in all research activities as needed; ensure the completion of high-quality projects within established budgets and time schedules; provide guidance and technical advice to those assigned to projects by evaluating performance, implement corrective actions and provide professional development to staff; review preparation of project deliverables; interact with technical reviewers and agencies to assure technical quality requirements are met in accordance with contract specifications.

Task 3: Fish Collection

Geir Aasen, Department of Fish and Game, 4001 North Wilson Way, Stockton, CA 95205.

Collection and transport of field collected fishes to UC Davis fish holding facilities, record keeping for fish collection results and reporting threatened and endangered fishes take.

Tasks 4, 5, and 6: Biological Monitoring/Research Plan, Quarterly Reports, Final Technical Report

Prepare BM/RP, quarterly reports and final technical report as scheduled in the Scope for Service.

B. Other Personnel

QA Officer:

Ken Bates, P. E.

Consultant to California Department of Water Resources

5211 Blvd. SE, Olympia, WA 98501.

(306) 902-2545, bateskmb@dfw.wa.gov.

Reports to the principal investigators and is independent of research staff; reviews QA/QC plans and reports for completeness and content, and signs off on the QAPP and reports, responsible for monitoring QC activities to determine compliance, distributing quality related information.

Hydraulics Laboratory Research Engineers:

Design, modification, operation, maintenance of Fish Treadmill; develop hydraulics designs and protocols; conduct hydraulics experiments; analyze and interpret results; prepare reports and journal articles.

Post-doctoral Biological Researchers:

Develop experimental designs and protocols; supervise research assistants and student assistants; conduct experiments; analyze and interpret results; prepare reports and journal articles.

State Agency Biologists:

Collaborate and assist team leaders in the development of experimental designs and protocols, supervision of research assistants, implementation of experiments, analyses and interpretation of results, preparation of reports and journal articles; act as liaison between UCD researchers and various state and federal Agencies.

State Agency Engineers:

Collaborate and assist team leaders in the development of experimental designs and protocols; provide technical assistance in the design and construction of research equipment and accessories; assist with Fish Treadmill modifications and improvements; act as liaison between UCD researchers and various state and federal Agencies.

Hydraulics Laboratory Technicians:

Perform manufacturing and installing modifications to the Fish Treadmill; maintaining Fish Treadmill apparatus.

Research assistants:

Assist in the construction of fish holding facilities, fish collection, fish care, facilities maintenance, preparation, implementation and termination of experiments, data collection, entry and preliminary analyses of data, preparation of reports and journal articles, and supervision of student assistants.

Student assistants:

Assist in fish collection, fish care, facilities maintenance, preparation, implementation and termination of experiments, data collection, entry and data analyses.

C. Training Requirements for Project Personnel

Training will be provided for all research staff, including state agency biologists, UC Davis research assistants, and student assistants. While many of the personnel involved in the project have background in fish biology, fish handling and care, experimental protocols and methods, and specific data collection techniques applicable to this project, no one will be allowed to work independently on the project until trained to the satisfaction of the principal investigator (biological research) or post-doctoral researchers. Training will be provided by the principal investigator, post-doctoral researchers, and when appropriate, state and federal agency biologists. It will be conducted on-site and on an individual basis. It will include background information on the project objectives, rationale, and overall methods as well as information and hands-on practice for specific project activities. Specific topics include:

- fish collection techniques and protocols
- fish care and feeding techniques and protocols
- fish handling techniques and protocols
- basic maintenance and operation of the fish holding facilities
- water quality measurements
- experimental protocols
- data collection techniques and protocols
- data entry and preliminary analyses
- laboratory safety

A training checklist will be used to verify training completeness and provide a written

record of training. Performance of all staff and student researchers will be evaluated and discussed weekly at the project staff meeting and additional training provided as required. Evaluation will include: observation and feedback by principal investigator and post-doctoral researchers; comparison of results obtained by individual researchers with those obtained by other researchers and trainers.

III. Measurement And Data Acquisition

A. Experimental Apparatus

All two-vector flow field experiments will be conducted using the Fish Treadmill prototype located at the UC Davis Hydraulic Laboratory. The Fish Treadmill is designed to produce a relatively uniform flow field (similar to that typical near large, flat-plate fish screens) within an annular swimming chamber in which fish can be confined. The outer ring of the swimming chamber consists of perforated plate-type fish screen and the inner ring, which is intended to simulate the flat plate fish screen, consists of vertical wedgewire-type fish screen. Other types of fish screens (e.g., horizontal wedgewire) may be installed in the inner ring for additional tests at a later date. Water depth in the swimming channel, approach velocity, and sweeping velocity of the water in the swimming channel are controlled collectively by the rotation rate of the outer screen and flow rates through the inflow control valve and the outflow control valve. The approach velocity is the velocity component perpendicular to the screen. The sweeping velocity is the velocity component parallel to the inner screen. Viewed from the top, the outer screen rotates in a counter-clockwise direction.

Water for the Fish Treadmill is supplied from a dedicated well. During treadmill operation water, a total volume of 60,000 gal circulates (circulation rate: up to 10,000 gal/min) between the treadmill and an underground sump tank. During operation there is no flow-through or make-up water from the well into the treadmill/sump system. Water temperature is controlled by a 30 HP combination heating and chilling system plumbed to circulate water in the sump tank (circulation rate: 200-350 gal/min). Water in the treadmill/sump system will be partially replaced (50%) with well water every two months or more frequently if necessary to maintain acceptable water quality. Immediately after water replacement, dissolved gases (e.g., oxygen, nitrogen) in the water in the treadmill/sump system will be equilibrated with atmospheric conditions, and water temperature adjusted to required experimental levels by circulating water between the sump, treadmill, and the heating/chilling system for at least 24 h prior to experiments.

To ensure a clear visual field for both visual observers and video cameras, the Fish Treadmill is equipped with plexiglass view plates that are attached to the inner screen at the water surface at four locations. One of these view plates covers the water from the inner screen to approximately 5 cm from the outer screen (large view plate), the other three view plates extend approximately 15 cm from the inner screen. Five video cameras are positioned at selected locations above the Fish Treadmill swimming channel (four cameras) and underwater (one camera, positioned downstream of the inner screen to view through the inner screen into the swimming channel). An additional large view plate is equipped with infra-red light emitters and each of the three small view plates used during day/light experiments can be equipped with a portable infra-red emitter array to enhance video and visual observations during the night experiments.

B. Experimental Variables

1. Units

For most biological and environmental variables defined in the following sections, measurements are expressed in metric units. However, since water diversion flow criteria are commonly expressed in English units, flow velocities from the Fish Treadmill will be initially defined and expressed as feet per second (f/s). During data reduction and analysis, these values will be converted into metric units. In all preliminary and final reports, velocity measurements will be expressed using both metric and English units.

2. Fish Species

While a number of Delta fish species are thought to be adversely affected by artificial flow regimes and screened barriers, priority for the Fish Treadmill experiments will be:

1. delta smelt (*Hypomesus transpacificus*) juveniles and adults,
2. Splittail (*Pogonichthys macrolepidotus*) young-of-the-year (YOY),
3. fall-run chinook salmon (*Oncorhynchus tshawytscha*) parr and smolts,
4. steelhead trout, *Oncorhynchus mykiss* parr and smolts, and
5. other small size and/or juvenile Delta fishes (e.g., American shad (*Alosa sapidissima*) YOY; striped bass, *Morone saxatilis*; longfin smelt, *Spirinchus thaleichthys*) depending on time and availability of adequate supplies of fish.

This priority order is based on the threatened status of delta smelt, and the "candidate" status of splittail, the endangered status of winter-run chinook salmon, and the threatened status of steelhead trout. American shad are included in these experiments to allow direct comparisons with previous experiments (Kano, 1982), and because American shad are reported to be "weak" swimmers (Kano, 1982).

3. Fish Size

For each species, two size classes will be used in the experiments, <6 cm standard length (SL) and ≥ 6 cm SL. Size class for each experiment is defined by the mean size, SL, of the fish used in that experiment. Fish smaller than 3-4 cm in length, depending on species, may be too small to use in the experiments for several reasons: small fish may be able to escape and/or become entangled in the holes in the perforated plate outer ring screen (Young and Cech, 1997); fish this size may be difficult to collect from the field in adequate numbers (e.g., delta smelt); and/or these fish may be too small to be clearly visible in the Fish Treadmill swimming chamber using either video or visual observations. However, if fish <3-4 cm SL are obtained in sufficient numbers and preliminary experiments indicate that they cannot escape the swimming channel and can be observed effectively, these fish will be included in the experiments. Fish >8 cm SL will not be used in the experiments because fish of this size are presumed to be less vulnerable to entrainment and impingement at water diversions.

4. Flow Regime

The ten flow regimes, derived from combinations of four approach flow velocities and three sweeping flow velocities, to be tested using the Fish Treadmill are listed in the table below. Velocities are expressed as f/s and cm/s (in parentheses). "E" designates an experimental flow regime. "C" designates a control flow regime.

Flow Treatment	Approach	Sweeping
C-1	0	0
E-1	0.2 (6 cm/s)	0
E-2	0.33 (10 cm/s)	0
E-3	0.5 (15 cm/s)	0
E-4	0.2	1 (31 cm/s)
E-5	0.33	1
E-6	0.5	1
E-7	0.2	2 (62 cm/s)
E-8	0.33	2
E-9	0.5	2

5. Temperature

Experiments will be conducted at two seasonally appropriate temperature levels, 12°C in the winter and spring (approximately December-May) and 19°C in the summer and fall (June-November). For all of the fishes we plan to use in the Fish Treadmill experiments, size, season and temperature are closely linked. Therefore, not all species-size-temperature combinations will be tested.

6. Light and Time of Day

Experiments will be conducted under two light level/photophase (time of day) conditions: light conditions during the day and dark conditions during the night. Daytime light levels will be 100-350 lux. Nighttime light levels will be 0-3 lux. Day experiments will begin no earlier than 1 h after sunrise and end no later than 1 h before sunset. Night experiments will begin no sooner than 1 h after sunset and end no later than 1 h before sunrise. Unless preliminary results indicate that large size class fish (>6 cm SL) perform poorly relative to smaller fish, night experiments will be conducted using the small size class of each species only.

7. Number of Fish

All experiments will be conducted using 20 fish from a single species and size class (size class is defined by mean SL of the 20 fish used in the experiment). All fish will be used only one time in the treadmill experiments.

8. Experiment Duration

Duration of experiments will be two hours. A limited number of additional experiments with a six hour duration will be conducted with chinook salmon and American shad only and at flow regime E-4 and E-5 only, in order to provide data which are more directly comparable with Kano (1982).

9. Experiment Scheduling

Experiments and experimental conditions (e.g., temperature, species, flow regime) are scheduled based on several factors that are listed in order of priority below.

Season: Experimental temperature is determined by season; 12°C in the winter and spring (approximately December-May) and 19°C in the summer and fall (June-November).

Species Availability: Experiments with a particular species are conducted only if enough fish of that species are available (minimum number: 220 fish, enough for one experiment at each of the ten flow regimes) and in acceptable condition (i.e., fully acclimated, healthy). A lower minimum number of fish may be acceptable if the fish are required to complete a replicate or set of experiments from earlier in the season, the previous season and/or to replace experiments excluded from the data set because of errors or unacceptable conditions (see Data Acceptability).

Species Priority: If adequate numbers of more than one species is available, the fish will be used in order of priority (see Fish Species).

Fish Size: If more than one size class of a particular species is available in adequate condition and numbers, experiments will be conducted with the small size class fish first.

Flow Regime: Experiments are generally conducted in sets of ten, one experiment for each of the ten flow regimes, or one complete replicate. Within each replicate, the order in which the flow regimes are tested is random. Under certain circumstances, the flow regime schedule within a single replicate may depart from the randomized order.

- Specific flow regimes may be selected to replace experiments excluded from the data set because of errors or unacceptable conditions.

- Certain flow regimes require more researchers to optimally conduct the experiment (e.g., in the high velocity approach/low sweeping velocity flow regimes, the camera view plates require periodic cleaning to remove small bubbles which accumulate in order to maintain adequate visibility for visual observers and video cameras). Flow regime schedule may be modified to accommodate personnel availability.

C. Fish Collection

Delta smelt: Delta smelt will be collected from three sources, the Sacramento-San Joaquin estuary, the state and federal fish salvage facilities in the south Delta, and from the laboratory of S. I. Doroshov, Department of Animal Science, UC Davis. Field collected fish will be captured using methods described in Swanson et al. (1996). For all fish, handling and transport protocols will also be done according to Swanson et al. (1996).

Splittail: Sacramento splittail young-of-the-year (YOY) will be collected from the Sacramento River and Sacramento-San Joaquin estuary by seine net and/or from state and federal fish salvage facilities. Handling and transport protocols will be according to methods described in Swanson et al. (1996).

Chinook salmon and Steelhead trout: Fall-run chinook salmon parr will be collected from state and federal fish hatcheries on the Sacramento and tributary rivers. Handling and transport protocols will be similar to those used for delta smelt.

American shad: American shad YOY will be collected from the Sacramento-San Joaquin estuary and/or the state and federal fish salvage facilities using methods described in Swanson et al. (1996). Handling and transport protocols will be similar to those used for delta smelt.

Other Delta fishes: Other Delta fishes will be collected from the Sacramento-San Joaquin estuary, state and federal fish salvage facilities, and/or state, federal, and private fish hatcheries using methods for collection, handling, and transport similar to those described above

D. Fish Care

1. Fish holding facilities

Three fish facilities will be used to hold fish used in the Fish Treadmill experiments, two at the UC Davis Aquatic Center and one at the UC Davis Hydraulics Laboratory.

The Aquatic Center fish holding facilities consist of 14 1 m round tanks located in Rm #129 and nine 1.7 m round tanks located in a semi-enclosed outdoor shelter. All tanks are equipped with non-chlorinated, air-equilibrated, temperature-controlled, continuously flowing well water. Fish collected from the field and hatcheries will be initially held in Rm #129 for quarantine and prophylactic treatments.

The Hydraulics Laboratory fish holding facility consists of six 1 m round tanks and eight 0.5 m round tanks located within the laboratory building. All tanks are equipped with non-chlorinated, air-equilibrated, temperature-controlled, continuously flowing well water. This facility is primarily for holding fish immediately prior to and after use in the Fish Treadmill experiments.

2. Fish care

All fish in all facilities will be cared for according to the UC Davis Aquatic Center Animal Care Protocols. Some specific aspects of the fish care relevant to use of the fish in the treadmill experiments are outlined below.

Stocking density: <2g fish/l.

Flow rates: 500-1000ml/min (minimum: 500 ml/min) generating a flow velocity in the tank of <6 cm/s.

Diet: Silver Cup (Stirling H. Nelson & Sons, Murray, UT), BioKyowa Fry feed (BioKyowa, Inc., Cape Girardeau, MO), and live *Artemia* nauplii freshly hatched from brine shrimp cysts (Argent Chemical Co., Redmond, WA).

Feeding Rate: *Ad libitum* for artificial diets using automatic feeders which dispense food hourly during daylight hours. *Artemia* nauplii once or twice per day, depending on species and fish size.

Photoperiod: All fish will be maintained on natural (e.g., Aquatic Center outdoor facility) or simulated natural (e.g., both indoor facilities) photoperiod regimes.

Light Intensity: 30-300 lux at 5 cm above water surface.

Temperature: $\pm 1^{\circ}\text{C}$ of target acclimation temperature, measured daily.

Temperature acclimation: All fish will be acclimated to the appropriate acclimation temperature for a minimum of seven (7) days prior to use in the experiments.

Dissolved oxygen: >70% air-saturation, measured weekly.

pH: 7.0-9.0, measured weekly

Ammonia: <0.5 mg/l (as total N), measured weekly.

Alkalinity: measured monthly.

Hardness: measured monthly.

Disease treatment and prophylaxis: Fish will be treated within 2 days of collection and/or as necessary for bacterial infection using a nitrofurazone solution (dose: 10 mg/l) and for fungal infections using a formaldehyde solution (dose: 0.1 ml/l). No fish from a particular tank will be used in the experiments if they show evidence of disease or have been treated for disease within the previous 10 d.

Mortality: All mortalities and incidents of possible disease among fish held in any of the fish holding tanks at each of the fish holding facilities will be recorded and, if necessary samples will

be sent to the UC Davis Fish Pathology Laboratory (Dr. R. P. Hedrick, School Of Veterinary Medicine) for necropsy and diagnosis. Fish from a particular tank will not be used in the experiments if mortalities from that tank exceed 10% during the five days prior to the experiment. The batch history and source will be available and documented for all fish used in the experiments.

3. Pre- and Post-test Fish Care

All fish used in the Fish Treadmill experiments will be transported from the UCD Aquatic Center fish holding facility to the UCD Hydraulics Laboratory fish holding facility a minimum of three (3) days prior to use in the experiments. Transport water temperature will be $\pm 1^{\circ}\text{C}$ of acclimation temperature. At the Hydraulics Laboratory fish holding facilities, all fish will be maintained at the appropriate acclimation temperature and fed the same quantity and quality diet as at the Aquatic Center. All fish that have completed a Fish Treadmill experiment will be held at the Hydraulic Laboratory fish holding facility for a 48-h post-test survival evaluation period and post-test health assessment and/or sampling for measurement of blood and plasma parameters prior to transport back to the Aquatic Center fish holding facility and use in other experiments (i.e., experiments other than Fish Treadmill experiments) and/or release.

E. Experimental Protocol

The schedule and brief descriptions of activities associated with each treadmill experiment is outlined below.

Pre-test activities

Establishment of experimental flow regime in Fish Treadmill: Conducted by Hydraulics Laboratory personnel. Fish will be introduced into the Fish Treadmill when the flow regime is within the acceptable flow velocity parameters (see Data Acceptability). Pre-test flow measurements (see Measurements) will be made no more than 20 min prior to introduction of fish into treadmill.

Fish Treadmill water quality assessment: Conducted by Hydraulics Laboratory personnel. Fish will be introduced into the Fish Treadmill when water quality variables are within acceptable parameters (see Data Acceptability). Pre-test water quality measurements (see Measurements) will be made no more than 20 min prior to introduction of fish into treadmill.

Placement of camera view plates: The large camera view plate will be installed along the inner screen frame of the Fish Treadmill and the positions of small view plates (left in place between successive experiments) adjusted as necessary.

Light level measurement: Light level (lux) measured at 5 cm above the water surface at the large view plate observation station.

Pre-test health assessment of experimental fish: See Measurements.

Transport of fish to treadmill: After the flow regime and water quality parameters are determined to be within the acceptable range, the experimental fish will be placed in the Fish Introduction Container and carried to the Fish Treadmill, and the container partially submerged in the swimming chamber.

Experimental activities

Introduction of fish into treadmill: After a period of >2 min and <10 min, the Fish Introduction Container will be opened and the fish released into the treadmill. This is the beginning of the experiment, e.g., time 0 min.

Video tape recording: At time 0 min, each of the four video cameras will be activated (and proper operation verified) to begin recording the activity of the fish in the treadmill.

Visual observations of fish swimming behavior and performance: See Measurements.

Post-test activities

Post-test flow measurements: See Measurements. These measurements will be made <5 min prior to the end of the experiment and cessation of flow in the treadmill.

Post-test water quality measurements: See Measurements. These measurements will be made <5 min prior to the end of the experiment and cessation of flow in the treadmill.

Video tape recording ended: Video cameras turned off at the end of the experiment and cessation of flow in the treadmill.

Removal of large view plates: Large view plate is removed to allow fish collection from the treadmill.

Fish collection and transport: Fish crowding device is installed and fish crowded and collected into holding container using dip nets and beakers. Fish are carried to designated Hydraulics Laboratory tank and released for post-test holding period.

Blood sampling for physiological measurements: In those experiments where physiological responses are being measured, eight randomly selected fish will be euthanized immediately after collection or at selected times post-experiment and blood collected by caudal transection (see Measurements). The remaining 12 fish will be carried to designated Hydraulics Laboratory tank and released for post-test holding period.

Post-test fish health assessment: See Measurements.

Data sheets: Complete data sheets and records, preliminary review of data sheets and records for accuracy by the principal investigator (research) or post-doctoral researcher..

F. Measurements

1. Types, Frequency, and Numbers of Measurements

Pre-test Health Assessment: Pre-test health assessments will be made on 20 fish randomly selected from the Hydraulics Laboratory pre-test holding tanks and anesthetized with MS222 (tricaine methanesulfonate; 70-100 mg/l) at least once for each group of fish of a single species, size class, temperature level and light level treatment. Measurements will include identification to species, fish size and weight (standard, fork, and total length in cm, wet weight in g), visible anatomical abnormalities, damage to skin, scales, fins, and eyes, and evidence of disease. An additional pre-test assessment, made on each group of 20 fish selected for use in each experiment as they are collected for use in the experiment, includes identification to species, approximate size (length in cm), visual health assessment without anesthesia (e.g., visible anatomical abnormalities or evidence of disease), and information on duration of laboratory holding (weeks), and acclimation temperature, mortality, disease, and treatment history from the tank(s) in which the fish have been held.

Water Quality: Measured treadmill water quality parameters are temperature, dissolved oxygen, pH, ammonia, alkalinity, and hardness. Measurements and/or water samples will be taken from the treadmill swimming chamber during treadmill operation. Temperature, dissolved oxygen, pH, and ammonia will be measured at the beginning of each experiment (immediately prior to introduction of the fish into the treadmill) and at the end (immediately prior to cessation of the experimental treadmill flow regime and removal of the fish from the apparatus) of all treadmill experiments. Alkalinity and hardness will be measured every four weeks.

Flow Regime: Two values of the flow velocity components, the average approach velocity perpendicular to the inner screen and the mid-channel sweeping velocity parallel to the inner screen, are the controlling parameters for each flow regime. The average approach velocity will be calculated from the inflow discharge rate (Dynasonics Ultrasonics Flowmeter) and the water depth in the swimming channel at the inner screen (see Measurements, Methodology and Definitions for formulae). The mid-channel sweeping velocity will be measured using an electronic velocity meter (SonTec Acoustic Doppler Velocimeter) in the swimming channel at one location 12 inches from the inner screen and at a depth of 10.2 inches from the bottom. These measurements will be made at the beginning (immediately prior to introduction of the fish into the treadmill) and end (immediately prior to cessation of the experimental treadmill flow regime and removal of the fish from the apparatus) of all treadmill experiments.

Light Level: Light level (lux) will be measured at a height of 5 cm above the water surface <10 min before the start of each experiment.

Fish Behavior and Performance - Visual Observations: Visual observations will be made at a minimum of two locations in the treadmill swimming chamber (visual field each observation station: approximately 6% of the swimming chamber circumference). Measurements will be made for 5-min intervals (e.g., time 0-5 min, time 5-10 min) throughout the two-hour experiment. Measurements will be made on loss of equilibrium (number of incidents during each 5-min interval), screen contacts (tail contacts and body contacts; number of each type of contact during each 5-min interval), impingement (body contact for >5 min; number of fish impinged at each 5 min interval), and fish distribution (number of fish visible at each observation station at 10 min intervals, e.g., time 10 min, time 20 min, etc.). Equilibrium loss rates (equilibrium loss/fish*min), screen contact rates (contacts/fish*min), and impingement rates (# fish impinged/20 fish) will be calculated for each 5-min interval and fish distribution (random, regular, or clumped) for each 10-min interval. Mean values for the entire 2-hour experiment will also be calculated. Observations on fish depth strata (bottom, middle, or top third of the swimming channel water column) and general swimming behavior will be made and recorded periodically.

Fish Behavior and Performance - Video Analyses: Video tape from four video cameras suspended 0.5-1.5 m above the swimming chamber and the underwater camera will be analyzed using a computer-assisted, video capture/motion analysis system (Peak Performance Technologies, Inc., Englewood, CO). Measurements will be made on fish spatial position (lateral position, cm from inner screen; and depth, cm from bottom), fish orientation (degrees; angle to the screen, measured, and angle to water flow, calculated using Fish Treadmill flow vector profiles), swimming direction and rheotaxis (swimming with or against the sweeping flow), swimming velocity (cm/s; velocity over the ground, measured, and through the water, calculated from swimming direction, velocity over the ground, and Fish Treadmill flow velocity profiles), and distance traveled (cm; distance over the ground, measured, and through the water, calculated) for five fish at times 0, 5, 10, 20, 40, 60, 80, 100, 110, and 120 min in the experiment. Swimming velocity (cm/s; velocity over the ground, measured, and through the water, calculated from swimming direction, velocity over the ground, and Fish Treadmill flow velocity profiles), stroke (i.e., tail beat) frequency, stroke amplitude, stride length (calculated; distance traveled per stroke), and swimming behavior (i.e., discontinuous vs continuous stroking, steady vs burst swimming), will be measured for selected fish (minimum: 5 fish each experiment, selection based on swimming direction and behavior) in each experiment (day/light conditions only).

Post-test Health and Survival Assessment: Post-test observations and measurements will include survival (up to 48 h post-test in holding tanks with minimal handling), fish size and weight (length; cm, standard, fork and total length; wet weight, g), health assessment (visible anatomical damage to skin, scales, fins, eyes, signs of diseases, etc.). Survival will be measured at 0 h and 48 h post-test. During the 48-h post-test period survival will be assessed every 12 h (minimum). Fish size, weight, and health assessment will be measured for all surviving fish 48 h post-test and, for any fish which die during the experiment, within 12 h of death. For fish which are sacrificed for physiological measurements, these measurements will be made immediately after death.

Physiological Responses: In selected experiments from all 10 flow regimes with large size class fish (minimum: 2 of 3 replicate experiments), eight fish will be sacrificed at selected times after the end of the experiment (0 min or immediately after collection, and 30 minutes, 2 hours, and 24 hours after the end of the experiment; two fish each sample) and blood collected by caudal transection for measurements of blood hematocrit, and plasma [cortisol], [lactate], [glucose], [Cl⁻] and pH. A minimum of two of the remaining 12 fish used in the 48 hour post-test survival assessment will be sampled similarly 48 hours after the end of the experiment. Control (i.e., resting) samples will be collected from a minimum of 2 fish randomly selected from Hydraulics Laboratory pre-test holding tanks. Samples from fish (collected as above) used in the C-1 flow regime (0 f/s approach/0 f/s sweeping) will be the handling control. Because of the expected volume of blood required to perform these tests, blood from the two fish at each sampling interval will be pooled for analyses.

2. Methods and Definitions

The following sections briefly outline how each of the measurements described above will be made.

Pre-test Health Assessment

Species identification: Visual inspection, comparison using appropriate fish key(s) (Miller and Lea, 1972; Moyle, 1976; Wang, 1986, 1991; Sweetnam, 1995) and laboratory fish care log book.

Acclimation conditions: Aquatic Center and Hydraulics Laboratory fish care log books.

Duration of laboratory holding: Fish collection data sheets and Aquatic Center fish care log books.

Approximate size: Visual inspection during collection for use in experiments.

Length and weight: Measured on anesthetized fish as standard, fork, and total length, and wet weight in g.

Health assessment: Visual inspection on anesthetized fish and during collection for use in experiments.

Mortality and disease history: Aquatic Center fish care log book.

Water Quality

All measurements will be made according to American Public Health Association et al. (1995).

Temperature: Calibrated electronic temperature sensor and/or certified mercury thermometer.

Dissolved oxygen: Electronic dissolved oxygen meter (Royce Model 900CE, Royce Instrument Co.)

pH: Hand-held electronic pH meter (Model pHep2; Hanna Instruments, Woonsocket, RI)

Ammonia: Hach ammonia test kit

Alkalinity: Aquatic Toxicology Laboratory, UCD

Hardness: Aquatic Toxicology Laboratory, UCD

Flow Regime

Approach and sweeping flow velocities: Measured using a SonTec Acoustic Doppler Velocimeter in f/s at 131 locations (3 sections in the circular swimming channel, 3 lateral locations in each section, 10-11 depths in each location, and an additional 35 measurements near the inner screen) for each experimental flow regime. These measured values are used to generate detailed flow velocity profiles.

Average approach flow velocity: This value is used as a controlling parameter for establishing the specified flow regime in each experiment. It is calculated as:

$$V_a(f/s) = Q(gpm) / (12684 \times H(ft))$$

where

Q = inflow discharge rate measured with Dynasonics Ultrasonic Flowmeter in gallons per minute (gpm); and

H = water depth in the swimming channel at the inner screen measured with an A. B.

McIntyre Hydraulics Instruments micrometer in feet (f).

Mid-channel sweeping flow velocity: Measured using a SonTec Acoustic Doppler Velocimeter in f/s at one location 12 inches from the inner screen and at a depth of 10.2 inches from the bottom. This value is used as a controlling parameter for establishing the specified flow regime in each experiment.

Resultant flow velocity: Calculated from approach and sweeping flow velocities at selected lateral and vertical locations within the swimming channel using from flow velocity profiles for each flow regime.

$$\text{Resultant flow velocity} = \sqrt{(\text{approach}^2) + (\text{sweeping}^2)}$$

Resultant flow vector: Calculated from approach and sweeping flow velocities at selected lateral and vertical locations within the swimming channel using flow velocity profiles for each flow regime.

$$\text{Resultant flow vector} = \arctan(\text{approach flow velocity} / \text{sweeping flow velocity})$$

Light Level

Light level (lux) measured using a photometer (Model LI-185A; LI-COR Inc.)

Fish Behavior and Performance - Visual Observations

Fish depth strata: Estimated as location in the bottom, middle, or top third of the water column.

Loss of equilibrium: Visual observation of lateral or longitudinal rolling by the fish to at least 90° from vertical, detected by observation of the fish's light colored ventrum.

Tail contact: Contact with the inner screen by the fish's caudal fin or <50% of the posterior body length.

Body contact: Contact with the inner screen by >50% of the fish's body length.

Impingement: Prolonged body contact, >5 min duration, with the inner screen by the fish.

Fish distribution: Number of fish visible in the observation area of the swimming channel defined by the view plate between the inner and outer screens.

Fish Behavior and Performance - Video Analyses

Motion analysis: Video tapes from one of the cameras will be analyzed manually and using a computer assisted, video capture/motion analysis system (Peak Performance Technologies, Inc., Englewood, CO) which tracks fish position, angle of orientation, and distance from selected reference points in an XY coordinate system for each frame of selected video tape. For each

section of video tape analyzed (e.g., 0.5 seconds or 30 frames), a mean value for each variable described below will be calculated for each fish analyzed.

Fish spatial location: Distance from inner screen, calculated using calibrated, scaled coordinates of the fish and the inner screen at the point closest to the fish. Depth, cm from the bottom, will be measured manually from video tapes from the underwater camera concurrently with the motion analyses of video tape from the same experiment.

Swimming direction and rheotaxis: Measured from fish orientation relative to the resultant flow vector or relative to the counter-clockwise direction for experiment in which sweeping flow=0 f/s as swimming with the flow (negative rheotaxis) or swimming against the flow (positive rheotaxis).

Swimming velocity: Swimming velocity over the ground calculated from scaled XY coordinates and time (automatic calculation by the Peak Performance software). Swimming velocity through the water calculated from swimming velocity over the ground and water velocity in the region of the swimming channel in which the fish is swimming. Swimming velocity through the water is calculated for the X and Y axes and as resultant swimming velocity.

Distance traveled: Calculated as the product of swimming velocity (cm/s, either over the ground or through the water) and time interval duration (e.g., in 1 min, 1 h, or 2 h).

Fish orientation: Fish orientation relative to the inner screen, measured in degrees for a single frame of the section of taped analyzed for motion analysis. Fish orientation relative to the resultant flow vector will be calculated from motion analysis measurement of fish orientation in the XY coordinates and flow vector profiles.

Stroke frequency: Measured as strokes/sec for single fish. Resultant swimming velocity through the water is also measured (as above) for the same fish from the same section of video tape.

Stroke amplitude: Maximum lateral displacement of the caudal peduncle, measured from scaled XY coordinates using the motion analysis system. Resultant swimming velocity through the water and stroke frequency are also calculated (as above) for the same fish.

Stride length: Distance (cm and as proportion of SL) traveled by the fish per stroke. Calculated as swimming velocity divided by stroke frequency.

Swimming behavior: Identified as low velocity discontinuous ("stroke and glide"), continuous, or high velocity discontinuous (i.e., burst) swimming based in swimming velocity, and stroking pattern.

Loss of equilibrium: Same as visual observations.

Tail and body contacts: Same as visual observations.

Post-test health Assessment

Survival: Assessed as number of fish alive out of 20 fish at the end of each experiment (0 h post-experiment) and at 48 h after the end of the experiment. Mortality is defined by cessation of ventilation or opercular movement for >1 min in non-swimming fish, lack of response to constant prodding, rigor mortis.

Size: Wet weight (± 0.01 g) and standard, fork, and total lengths (± 0.1 cm).

Health Assessment: Visual observation for evidence of disease, morphological abnormalities, and physical damage to skin, scales, fins, and eyes (e.g., abrasion, scale loss, hemorrhaging).

Physiological Responses

Hematocrit: Measured using an IEC micro-hematocrit reader after centrifugation of capillary tubes with blood samples at 11,000 x gravity for 3 min.

Cortisol: Measured using radioimmunoassay (Brown et al., 1987).

Lactate and Glucose: Measured simultaneously using a YSI 2700 Select Biochemistry Analyzer (Yellow Springs Instruments, Inc., Yellow Springs, OH).

Osmolality: Measured using a Wescor 5100B Vapor Pressure Osmometer (Wescor, Inc., Logan, UT).

pH: Measured using an Orion Model SA 720 pH meter.

G. Data Quality Objectives

The following section describes the data quality objectives (DQOs) of the variables or characteristics which will be measured or recorded as part of the experiments. Data quality objectives are quantitative and qualitative statements describing the accuracy, precision, representativeness, comparability, and completeness goals for the measuring or classifying systems used (USEPA, 1996). These DQOs specify the quality of the data needed to meet the goals of the biological experiments. Generally, all measurements or observations should be:

- representative of the typical conditions found in the test chamber in the immediate vicinity of the location monitored at the time the measurement is taken;
- representative of the performance, behavior, and physiology of fish exposed to the above conditions.
- "True values" refer to properly measured variables based on the proper calibration procedures and standards of the instrument.

All measurements of a variable should be comparable to each other, and should be comparable to similar data collected by other researchers in North America. At least 90% of the measurements collected should meet the data quality objectives of the project. The accuracy and precision objectives for variables measured during the routine biological experiments are discussed below.

1. Pre- and Post-Test Health Assessments

Species Identification: No accuracy objective is available for this variable. Fish identification by two trained personnel should agree. Any fish that can not be identified using keys found in Moyle (1976), Miller and Lea (1972), Wang (1986, 1991), and Sweetnam (1995) with certainty will not be used in the experiments.

Health Assessment: No accuracy objective is available for this variable. At least 80% of the health assessments made by two trained personnel should agree.

Fish Weight (Wet): Measured values should be within 0.1 g of the true values. Replicate measurements should be within 0.15 g each other. Fish weight will be reported as wet weight (g).

Fish Length: Measured values should be within 0.1 cm of the true values. Replicate measurements should be within 0.15 cm each other. Fish length will be reported as standard length (SL), total length (TL), and fork length (FL) in cm.

Survival/Mortality: No accuracy objective is set for this parameter. At least 90% of the observations regarding the determination of mortality made by two trained personnel should agree. Personnel will use multiple criteria to determine death of the test organism (e.g., lack of gill movement, lack of response to constant prodding, rigor mortis).

2. Water Quality

Water Temperature: Measured values should be within 0.5°C of the true values (based on calibrations using certified thermometer). Replicate measurements should be within 0.3°C of each other. During the biological experiments, the mean water temperature should not deviate more than 1.0°C from the target experimental temperature. Measurements of water temperature in the Fish Treadmill will be made at least once every 60 min during experiments.

Dissolved Oxygen: Measured values should be within 0.5 mg/l of the true values. Replicate measurements should be within 0.25 mg/l of each other. A reading will be taken twice during each experiment, at the start and end of the experiment.

pH: Measured values should be within 0.3 pH units of the true values. Replicate measurements should be within 0.5 pH units of each other. A reading should be taken twice during each experiment, at the start and end of the experiment.

Total Ammonia: Measured values should be within 0.1 mg/l as N or 10% of the true values.

Replicate measurements should be within 0.05 mg/l as N or 15% of the true values.

Measurements will be recorded at the start and end of each experiment.

Alkalinity: No accuracy objective is available for this parameter. Replicate measurements should be within 5 mg/l as CaCO₃ or 5% of each other. Measurement will be recorded for each set of experiments using the same water from the sump.

Total Hardness: Measured values should be within either 3 mg/l as CaCO₃ or 3% of the true values. Replicate measurements should be within 5 mg/l as CaCO₃ or 5% of each other.

Measurement will be recorded for each set of experiments using the same water from the sump.

3. Flow Regime

Inflow discharge rate: Measured values should be within 0.5 cfs of the true values. Replicate measurements should be within 0.4 cfs of each other.

Water depth: Measured values should be within 0.5 in of the true values. Replicate measurements should be within 0.3 in of each other.

Sweeping flow velocity: Measured values should be within 2.0 cm s⁻¹ (0.066 f/s) of the true values. Replicate measurements should be within 2.0 cm s⁻¹ (0.066 f/s) of each other.

Approach flow velocity: Measured values should be within 1.0 cm s⁻¹ of the true values. Replicate measurements should be within 0.5 cm s⁻¹ of each other.

Mid-channel sweeping flow velocity: Measured values should be within 2.0 cm s⁻¹ (0.066 f/s) of the true values. Replicate measurements should be within 2.0 cm s⁻¹ (0.066 f/s) of each other.

4. Light Level

Measured values should be within 10 lux of the true values (based on calibration procedures).

Replicate measurements should be within 5 lux of each other or have a relative percent difference (RPD) ≤ 5%.

5. Fish Behavior and Performance - Visual Observations

Depth strata: No accuracy objective is set for this parameter. Because of the difficulty in estimating fish depth, observations will be limited to classifying fish depth in three strata (e.g., surface, mid-depth, bottom). At least 80% of the observations regarding location of fish in depth strata made by two trained personnel should agree.

Loss of equilibrium: No accuracy objective is set for this parameter. At least 80% of the

observations regarding the determination of the loss of equilibrium made by two trained personnel should agree.

Tail contact: No accuracy objective is set for this parameter. At least 80% of the observations regarding numeration and description of tail contact made by two trained personnel should agree.

Body contact: No accuracy objective is set for this parameter. At least 80% of the observations regarding numeration and description of body contact made by two trained personnel should agree.

Impingement: No accuracy objective is set for this parameter. At least 80% of the observations regarding numeration and description of impingement made by two trained personnel should agree.

Fish distribution: No accuracy objective is set for this parameter. At least 80% of the observations regarding numeration of fish visible in the observation area at the designated time made by two trained personnel should agree.

6. Fish Behavior and Performance - Video Analyses

Fish Spatial Position: Calculated coordinate values for distance from inner screen should be within 3.0 cm of the true values. Replicate measurements should be within 2.0 cm of each other. Manual estimation of depth should be within 5.0 cm of the true values. Replicate measurements should be within 3.0 cm of each other.

Swimming direction, rheotaxis, and fish orientation: Measured values should be within 10 degrees of the true angles. Replicate measurements should be within 5 degrees of each other.

Swimming velocity (over the ground): Calculated values for swimming velocity (over the ground) should be within 3 cm/s of true values. Replicate measurements should be within 2.0 cm/s of each other.

Swimming velocity (through the water): Calculated values for swimming velocity (over the ground) should be within 6 cm/s of true values. Replicate measurements should be within 3.0 cm/s of each other.

Stroke frequency: Counts of stroke number per unit time should be within 1 stroke of true values. Replicate counts should be within 1 stroke of each other.

Stroke amplitude: Calculated values should be within 0.5 cm of true values. Replicate measurements should be within 0.5 cm of each other.

Stride length: Calculated values should be within 1.0 cm of true values. Replicate measurements should be within 1.0 cm of each other.

Swimming behavior: No accuracy objective is set for this parameter. At least 80% of the replicate observations regarding identification of swimming behavior made by two trained personnel should agree.

Loss of Equilibrium: No accuracy objective is set for this parameter. At least 80% of the replicate observations regarding identification of loss of equilibrium made by two trained personnel should agree.

Tail contact: No accuracy objective is set for this parameter. At least 80% of the observations regarding numeration and description of tail contact made by two trained personnel should agree.

Body contact: No accuracy objective is set for this parameter. At least 80% of the observations regarding numeration and description of body contact made by two trained personnel should agree.

7. Physiological responses

Blood Hematocrit: Measured values should be within 1.0% volume red blood cells of true values. Replicate measurements should be within 10% of each other.

Plasma Cortisol: Measured values should be within 0.1 ng ml^{-1} of the true values. Replicate measurements should be within 0.05 ng ml^{-1} of each other.

Plasma Lactate: Measured values should be within 0.1 mM l^{-1} of the true values. Replicate measurements should be within 0.05 mM l^{-1} of each other.

Plasma Glucose: Measured values should be within 0.1 mM l^{-1} of the true values. Replicate measurements should be within 0.05 mM l^{-1} of each other.

Plasma Osmolality: Measured values should be within 1.0 mOsm kg^{-1} of the true values. Replicate measurements should be within 1.0 mOsm kg^{-1} of each other.

Plasma pH: Measured values should be within 0.3 pH units of true values. Replicate measurements should be within 0.3 pH units of each other.

H. Calibration Procedures and Frequency

1. Flow Regime

The Fish Treadmill will be calibrated and detailed flow profiles developed for the nine experimental flow regimes every six months. Calibrations will be conducted at the two test temperatures (12 and 19°C, one temperature every six months). The SonTec Acoustic Doppler Velocimeter used to measure flow velocity and direction in the Fish Treadmill will be calibrated according to manufacturer's specifications as defined in the user's manuals.

2. Light Level

Light level and light placement will be calibrated and adjusted as necessary using light level measurements made at 24 locations (8 sections, 3 lateral locations each section; near inner screen, mid-channel, and near outer screen) twice per year.

3. Analytical Equipment

All analytical equipment (e.g., dissolved oxygen meter, pH meter, osmometer, etc.) will be calibrated according to manufacturers' specifications as defined in the user's manuals.

4. Motion Analysis

Calibration and scaling of video images, to convert computer/monitor pixel dimensions into linear metric units, will be conducted for each camera using procedures outlined in the operator's manual and the program's online help manual. The scaling rod will consist of two permanent markers of retro-reflective tape placed on the upper surface of the large view plates. Distance between the markers will be checked using a standard linear scale at monthly intervals, although it is not expected that the marker's positions will change. Motion analysis of each videotape will begin with this calibration/scaling procedure and all motion analyses from that tape will incorporate the scaling factor for measurements and calculations.

I. Data Documentation

All laboratory and field activities will be documented at the time they are conducted. Documentation type (e.g., data sheets, laboratory log books) will vary depending on activity. Specific documentation is described below.

Fish Collection: Data sheets from each collection will include information on personnel, location, species, collection conditions (e.g., temperature and salinity), weather conditions, number of fish collected, and general notes on fish condition and other relevant information as necessary.

Fish Care: Laboratory log books for each fish holding facility will include information recorded daily on personnel, feeding, cleaning, water quality (e.g., temperature), all prophylactic and anti-disease treatments, mortality and health assessments, other relevant information on fish and/or fish holding facility status.

Fish Treadmill Experiments: Data collected from treadmill experiments will be documented on separate data sheets for various aspects of the experiment and experimental conditions. All data sheets will include information on date, time, species, experimental flow regime, temperature, light level, and personnel. Separate data sheets will be used for:

- water quality and flow regime;
- pre- and post-test fish health assessments;
- visual observations of fish in the treadmill;
- data recording and analyses from video tape records of the treadmill experiments;
- post-test physiological measurements.

All treadmill experiments will also be video recorded using five video cameras mounted above the treadmill swimming chamber and underwater (see Experimental Apparatus, and Measurements). Video tapes will be stored at the UC Davis Hydraulics Laboratory or Academic Surge Building, Rm 1331, prior to analysis and data collection on fish swimming performance and behavior. After analyses, video tapes will be archived at the Fish Physiology Laboratory (UCD Academic Surge building) and available for follow-up analyses for data checking purposes and/or additional analyses.

IV. DATA REDUCTION, ANALYSES, AND REPORTING

A. Data Reduction and File Management

1. Pre- and Post-test Health Assessments

Pre- and post-test health assessment data and reduced physiological response data (see Physiological Responses below) will be compiled into a Fish Status data file. Summarized data from this file (e.g., duration of laboratory holding pre-test, survival, blood parameters) will be included in other data files (e.g., Fish Performance, see below) for incorporation into subsequent statistical analyses (see Statistical Methods). Fish size data (e.g., mean standard lengths) will also be included in the Fish Performance and Fish Behavior data files (see below) in order to allow calculation of relative swimming velocities and distance values and to test for effects of fish size on performance and behavior.

2. Water Quality, Flow Regime, and Light Levels

Data on fish treadmill water quality, flow regime, and light levels will be incorporated into an Flow and Environmental Conditions data file and will be analyzed to assess the variability of the experimental conditions. Reduced data from some variables (e.g., water temperature) will also be included in Fish Performance and Fish Behavior data files.

3. Fish Behavior and Performance

a. Visual Observations

Data from visual observation data sheets will be included in Fish Performance data files.

b. Video Analysis

Data on fish spatial position, velocities, distances, and orientation collected using motion analysis will be incorporated into Fish Behavior data files. Data on swimming kinematics (e.g. stroke frequency, stride length) collected using motion analysis will be incorporated into a Kinematics data file.

c. Fish Performance

A Fish Performance data file will include data on species, experimental conditions (e.g., temperature, flow regime, light level), visual observation data, video analysis data, and reduced data from the Fish Status data file (e.g., survival rates, physiological responses). It will be generated using data from visual observation data sheets, manual video analysis, reduced motion-analysis data, reduced data from the Flow and Environmental Conditions data file (e.g., temperature) and Fish Treadmill flow profiles.

d. Fish Behavior

A Fish Behavior data file will include data on species, fish size (from Fish Status data files) experimental conditions (e.g., temperature, flow regime, light level, etc., from Flow and Environmental Conditions data files), water velocity at the specified location (from Fish Treadmill flow profiles) and swimming behavior (e.g., spatial position, velocities, etc., from motion analysis data sheets).

e. Physiological Responses

Data from the measured physiological responses (e.g., plasma cortisol, etc.) and data from the Fish Status data files (e.g., survival, size) and experimental conditions (e.g., temperature, flow regime, light level, etc., from Flow and Environmental Conditions data files) will be incorporated into a Physiological Response data file.

B. Statistical Methods

Results compiled in the files described above will be analyzed using Sigmapstat and Systat software. Statistical analyses will include: comparisons among appropriate treatment groups (e.g., species, flow regime, light level, etc.) made using analysis of variance and two-tailed t-tests; regression analyses and analysis of covariance for examination of the effects of continuous variables (e.g., time, swimming velocity) and categorical covariates (e.g., temperature); nonparametric tests (e.g., Mann-Whitney Rank Sum test) for comparisons of treatment groups for which the data are not normally distributed.

V. DATA ASSESSMENT AND OVERSIGHT

A. Data Quality Control Checks

1. Data Acceptability

Listed below (or referenced in the specified section of this document) are the acceptable ranges of selected biological, environmental, and experimental conditions for the pre-test, test, and post-test periods for the Fish Treadmill experiments. Conditions that deviate from these acceptable ranges may be considered as rationale for a) excluding or postponing the use of selected fish from the experiments; b) canceling a planned experiment; and/or c) excluding some or all of the data collected during an experiment (e.g., if water temperature in the Fish Treadmill is unacceptable, all data collected during the experiment must be evaluated separately and, possibly, excluded from the data set; however, if post-test holding tank temperature is unacceptable, all data from the experiment with the exception of post-test survival and health assessment may be used).

Pre-test Health and Fish Care Conditions

Temperature Acclimation: Minimum 7 days at experimental temperature.

Holding Tank Temperature: $\pm 1.0^{\circ}\text{C}$ of specified test temperature. If Hydraulics Laboratory tank temperatures deviate from specified test temperature, the temperature will be adjusted $1.0^{\circ}\text{C}/\text{day}$ and the fish held a minimum of one day after the temperature has been adjusted to the correct level before they are used in the experiments.

Disease History: No fish from a holding tank that has been treated for bacterial or fungal infections in the previous 10 d will be used in the experiments.

Mortality History: No fish from a tank that has experienced $>10\%$ mortality (excluding transport mortality) in the five days prior to use in the experiments will be used in the experiments

Transport History: All fish will spend a minimum of three days in Hydraulics Laboratory fish holding tanks prior to use in the experiments.

Experimental Variables

Listed below are the acceptable water quality ranges for specific parameters.

Fish Treadmill Water Temperature: $\pm 1.0^{\circ}\text{C}$ of specified test temperature.

Fish Treadmill Dissolved Oxygen: $>70\%$ air-saturation.

Fish Treadmill pH: >7.0 or <9.0 pH units.

Fish Treadmill Ammonia: <0.5 mg/l (as total N).

Flow Regime: ± 3 cm/s for the approach flow velocity, ± 6 cm/s for the sweeping flow velocity.

Post-test Conditions

Holding Tank Temperature, Dissolved Oxygen, pH, and Ammonia: same range as for the Fish Treadmill.

Fish Size: If data on fish size are lost or unavailable for all fish used in an experiment, estimated size ranges from pre-test log books and data sheets, will be used but data from the experiment will be evaluated separately before possible inclusion in the data set. If data on fish size of $<30\%$ of the fish used in the experiment are lost or unavailable, mean fish size values calculated from the remaining fish will be used in the data set.

2. Error Checking of Raw Data

Upon completion, all data sheets will be checked by the research assistant in charge of that

particular experiment, any errors or incomplete sections corrected, and the data sheet signed by the research assistant in charge. Completion and error checks will also be made at the time the data are entered into the data files. Any corrections made on data sheets after completion will be signed and dated by the research assistant in charge of the experiment or a post-doctoral researcher. During data entry, a minimum of 10% of the data entered in each data file (e.g., 1 row out of every 10 rows in the data file) will be double checked by a second trained research assistant or a post-doctoral researcher. Any questions or discrepancies will be investigated and corrected by the post-doctoral researchers. Specific data in which questions can not be resolved (e.g., unreadable) will not be included in the data sets.

3. Error checking of Reduced Data and Analyses

Reduced Data and Preliminary Analyses

All reduced data and preliminary analyses (e.g., summary statistics) will be checked by a trained research assistant and/or a post-doctoral researcher for errors, completeness, and correct execution of preliminary statistical tests. After this check, selected components of these data will be entered (and checked as above) in the appropriate data file(s) (see these Data Reduction and File Management) for further analyses.

Statistical Analyses

All statistical procedures will be conducted according to Sokal and Rohlf (1981), Snedecor and Cochran (1967), and other recognized and standard methods. The UCD Statistics Laboratory, which provides consultations with professional statisticians, will be consulted as necessary.

4. Performance and System Evaluation

All field and laboratory activities may be reviewed by the Principal Investigator, QA Officer, and post-doctoral researchers as requested. A QA/QC report summarizing the results of data quality control checks will be submitted to the QA Officer monthly. In the event data quality control objectives are not satisfied, the Principal Investigator, post-doctoral researchers, and State agency representatives will meet to determine the extent of the problem, discuss and develop corrective actions, oversee implementation of the corrective actions, and evaluate their effectiveness.

B. Agency and Peer Review

The Fish Treadmill project will be subjected to agency and peer review at several levels. Agency representatives (i.e., DWR, CDFG; see Project Organization, Responsibilities), in addition to participation in various aspects of the project and experiments, will meet regularly (two times per month) to discuss and evaluate progress, problems, and scheduling. The project will be more formally evaluated by agency representatives, representatives from cooperating agencies, and contract consultants at least once per year. Journal articles describing results of various aspects of the project will be submitted for publication in peer-reviewed scientific, water-related, and management journals (e.g., Transactions of the American Fisheries Society, North American Journal of Fisheries Management, Environmental Biology of Fishes, Copeia, Canadian Journal of Aquatic and Fisheries Sciences, Journal of Experimental Biology, Conservation Biology, Hydrobiologia, and Water Research).

VI. REFERENCES

- American Public Health Association, American Water Works Association, and Water Pollution Control Federation (1995) Standard methods for the examination of water and wastewater. 19th ed.
- Brown, C. L., W. M. Bailey, J. D. Bayless, K. E. Erickson, and R. E. Stevens (1987) Preliminary report on the physiological status of striped bass in the Carquinez Strait die-off. Fish. Res. 6:5-16.
- California Department of Fish and Game, and U. S. Bureau of Reclamation. 1994. Biological assessment: Effects of the Central Valley Project and State Water Project on delta smelt and Sacramento splittail. 230 pp.
- California Department of Fish and Game. 1997. Fish screen criteria. CDFG Memorandum. 6 pp.
- Kano, R. M. (1982) Responses of juvenile chinook salmon, *Oncorhynchus tshawytscha*, and American shad, *Alosa sapidissima*, to long term exposure to two-vector flows. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary. Technical Report 4. 20 pp.
- Kavvas, M. L., E. Velagic, Z.-Q. Chen, A. Karakas, et al. (1996) Fish screen test apparatus with variable two-vector flow conditions: hydraulic model. Report to the California Department of Water Resources. 36 pp.
- Kawasaki, S. and P. Raquel. 1995. Fish screens and water diversions. Valley Habitats. A Technical Guidance Series for Private Land Managers in California's Central Valley. No. 8. 8 pp.
- Miller, D. J. and R. N. Lea (1972) Guide to the coastal marine fishes of California. California Fish Bulletin Number 157. 249 pp.
- Moyle, P. B. (1996) Inland fishes of California. University of California Press, Berkeley. 405 pp.
- National Marine Fisheries Service. 1997. Fish screening criteria for anadromous salmonids. NMFS Southwest Region. 10 pp.
- Snedecor, G. W. And W. G Cochran. 1967. Statistical Methods. The Iowa State University Press, Ames, Iowa. 593 pp.
- Sokal, R. R. And F. J. Rohlf. 1981. Biometry. W. H. Freeman and Co., New York. 859 pp.
- Swanson, C., R. C. Mager, S. I. Doroshov, and J. J. Cech, Jr. (1996) Use of salts, anesthetics, and polymers to minimize handling and transport mortality in delta smelt. Trans. Am. Fish. Soc. 125:326-329.

Swanson, C., P. S. Young, J. J. Cech, Jr., R. Fujimura, and T. Frink (1998) Quality Assurance Project Plan. In *Performance, Behavior, and Physiology of Delta Fishes in Two-vector Flows in a Fish Treadmill*. Final Report to Department of Water Resources.

Sweetnam, D. (1995) Field identification of delta smelt and wakasagi. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Newsletter, Spring 1995:1-3.

United States Environmental Protection Agency (1996) Volunteer estuary monitoring: a methods manual. Office of Water. EPA842-B-93-004.

Velagic, E., Z. Q. Chen, A. Karakas, E. Dogrul, H. Bandeh, W. Summer, M. L. Kavvas, C. Swanson, P. S. Young, and J. J. Cech, Jr. 1998. Performance, behavior, and physiology of Delta fishes in variable two-vector flows. Progress Report to the California Department of Water Resources. 93 pp.

Wang, J. C. S. (1986) Fishes of the Sacramento-San Joaquin estuary and adjacent waters: a guide to the early life histories. Interagency Ecological Program for the Sacramento-San Joaquin Estuary. Technical Report 9.

Wang, J. C. S. (1991) Early life history stages and early life history of the delta smelt, *Hypomesus transpacificus*, in the Sacramento-San Joaquin estuary, with comparison of early life history stages of the longfin smelt, *Spirinchus thaleichthys*. Interagency Ecological Program for the Sacramento-San Joaquin Estuary. Technical Report 28. 52 pp.

NONDISCRIMINATION COMPLIANCE STATEMENT

STD. 19 (REV. 3-95)

COMPANY NAME

The company named above (hereinafter referred to as "prospective contractor") hereby certifies, unless specifically exempted, compliance with Government Code Section 12990 (a-f) and California Code of Regulations, Title 2, Division 4, Chapter 5 in matters relating to reporting requirements and the development, implementation and maintenance of a Nondiscrimination Program. Prospective contractor agrees not to unlawfully discriminate, harass or allow harassment against any employee or applicant for employment because of sex, race, color, ancestry, religious creed, national origin, physical disability (including HIV and AIDS), medical condition (cancer), age (over 40), marital status, denial of family care leave and denial of pregnancy disability leave.

CERTIFICATION

I, the official named below, hereby swear that I am duly authorized to legally bind the prospective contractor to the above described certification. I am fully aware that this certification, executed on the date and in the county below, is made under penalty of perjury under the laws of the State of California.

OFFICIAL'S NAME

**THE REGENTS OF THE UNIVERSITY
OF CALIFORNIA**

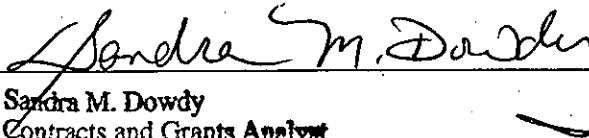
DATE EXECUTED

MAY 12 2000

EXECUTED IN THE COUNTY OF

YOLO

PROSPECTIVE CONTRACTOR'S SIGNATURE



PROSPECTIVE CONTRACTOR'S TITLE

**Sandra M. Dowdy
Contracts and Grants Analyst**

PROSPECTIVE CONTRACTOR'S LEGAL BUSINESS NAME

**Certifications Regarding Debarment, Suspension and
Other Responsibility Matters, Drug-Free Workplace
Requirements and Lobbying**

Persons signing this form should refer to the regulations referenced below for complete instructions:

Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transactions - (See Appendix B of Subpart D of 43 CFR Part 12.)

Certification Regarding Drug-Free Workplace Requirements - Alternate I. (Grantees Other Than Individuals) and Alternate II. (Grantees Who are Individuals) - (See Appendix C of Subpart D of 43 CFR Part 12.)

Signature on this form provides for compliance with certification requirements under 43 CFR Parts 12 and 18. The certifications shall be treated as a material representation of fact upon which reliance will be placed when the Department of the Interior determines to award the covered transaction, grant, cooperative agreement or loan.

Certification Regarding Debarment, Suspension, and Other Responsibility Matters - Primary Covered Transactions - The prospective primary participant further agrees by submitting this proposal that it will include the clause titled, "Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transaction," provided by the department or agency entering into this covered transaction, without modification, in all lower tier covered transactions and in all solicitations for lower tier covered transactions. See below for language to be used; use this form for certification and sign; or use Department of the Interior Form 1954 (DI-1954). (See Appendix A of Subpart D of 43 CFR Part 12.)

**PART A: Certification Regarding Debarment, Suspension, and Other Responsibility Matters -
Primary Covered Transactions**

CHECK ☐ IF THIS CERTIFICATION IS FOR A PRIMARY COVERED TRANSACTION AND IS APPLICABLE.

- (1) The prospective primary participant certifies to the best of its knowledge and belief, that it and its principals:
 - (a) Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency;
 - (b) Have not within a three year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;
 - (c) Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State or local) with commission of any of the offenses enumerated in paragraph (1)(b) of this certification; and
 - (d) Have not within a three year period preceding this application/proposal had one or more public transactions (Federal, State or local) terminated for cause or default.
- (2) Where the prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

**PART B: Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion -
Lower Tier Covered Transactions**

CHECK ☐ IF THIS CERTIFICATION IS FOR A LOWER TIER COVERED TRANSACTION AND IS APPLICABLE.

- (1) The prospective lower tier participant certifies, by submission of this proposal, that neither it nor its principals is presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participation in this transaction by any Federal department or agency.
- (2) Where the prospective lower tier participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

PART C: Certification Regarding Drug-Free Workplace Requirements

CHECK ☒ IF THIS CERTIFICATION IS FOR AN APPLICANT WHO IS NOT AN INDIVIDUAL.

Alternate I. (Grantees Other Than Individuals)

A. The grantee certifies that it will or continue to provide a drug-free workplace by:

- (a) Publishing a statement notifying employees that the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance is prohibited in the grantee's workplace and specifying the actions that will be taken against employees for violation of such prohibition;
- (b) Establishing an ongoing drug-free awareness program to inform employees about--
 - (1) The dangers of drug abuse in the workplace;
 - (2) The grantee's policy of maintaining a drug-free workplace;
 - (3) Any available drug counseling, rehabilitation, and employee assistance programs; and
 - (4) The penalties that may be imposed upon employees for drug abuse violations occurring in the workplace;
- (c) Making it a requirement that each employee to be engaged in the performance of the grant be given a copy of the statement required by paragraph (a);
- (d) Notifying the employee in the statement required by paragraph (a) that, as a condition of employment under the grant, the employee will --
 - (1) Abide by the terms of the statement; and
 - (2) Notify the employer in writing of his or her conviction for a violation of a criminal drug statute occurring in the workplace no later than five calendar days after such conviction;
- (e) Notifying the agency in writing, within ten calendar days after receiving notice under subparagraph (d)(2) from an employee or otherwise receiving actual notice of such conviction. Employers of convicted employees must provide notice, including position title, to every grant officer on whose grant activity the convicted employee was working, unless the Federal agency has designated a central point for the receipt of such notices. Notice shall include the identification number(s) of each affected grant;
- (f) Taking one of the following actions, within 30 calendar days of receiving notice under subparagraph (d)(2), with respect to any employee who is so convicted --
 - (1) Taking appropriate personnel action against such an employee, up to and including termination, consistent with the requirements of the Rehabilitation Act of 1973, as amended; or
 - (2) Requiring such employee to participate satisfactorily in a drug abuse assistance or rehabilitation program approved for such purposes by a Federal, State, or local health, law enforcement, or other appropriate agency;
- (g) Making a good faith effort to continue to maintain a drug-free workplace through implementation of paragraphs (a), (b), (c), (d), (e) and (f).

B. The grantee may insert in the space provided below the site(s) for the performance of work done in connection with the specific grant:

Place of Performance (Street address, city, county, state, zip code)

University of California

One Shields Ave.

Davis, CA 95616

Check ☐ if there are workplaces on file that are not identified here.

PART D: Certification Regarding Drug-Free Workplace Requirements

CHECK ☐ IF THIS CERTIFICATION IS FOR AN APPLICANT WHO IS AN INDIVIDUAL.

Alternate II. (Grantees Who Are Individuals)

- (a) The grantee certifies that, as a condition of the grant, he or she will not engage in the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance in conducting any activity with the grant;
- (b) If convicted of a criminal drug offense resulting from a violation occurring during the conduct of any grant activity, he or she will report the conviction, in writing, within 10 calendar days of the conviction, to the grant officer or other designee, unless the Federal agency designates a central point for the receipt of such notices. When notice is made to such a central point, it shall include the identification number(s) of each affected grant.

Certification Regarding Lobbying
Certification for Contracts, Grants, Loans, and Cooperative Agreements

CHECK ☐ IF CERTIFICATION IS FOR THE AWARD OF ANY OF THE FOLLOWING AND THE AMOUNT EXCEEDS \$100,000: A FEDERAL GRANT OR COOPERATIVE AGREEMENT, SUBCONTRACT, OR SUBGRANT UNDER THE GRANT OR COOPERATIVE AGREEMENT.

CHECK ☐ IF CERTIFICATION IS FOR THE AWARD OF A FEDERAL LOAN EXCEEDING THE AMOUNT OF \$150,000, OR A SUBGRANT OR SUBCONTRACT EXCEEDING \$100,000, UNDER THE LOAN.

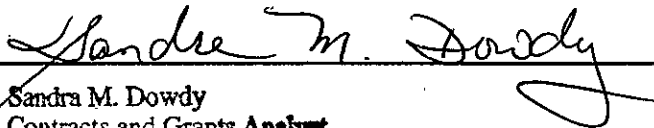
The undersigned certifies, to the best of his or her knowledge and belief, that:

- (1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, and officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
- (2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.
- (3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.

As the authorized certifying official, I hereby certify that the above specified certifications are true.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL


Sandra M. Dowdy
Contracts and Grants Analyst

TYPED NAME AND TITLE

MAY 12 2000

DATE

ASSURANCES - NON-CONSTRUCTION PROGRAMS

Public reporting burden for this collection of information is estimated to average 15 minutes per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Office of Management and Budget, Paperwork Reduction Project (0348-0040), Washington, DC 20503.

**PLEASE DO NOT RETURN YOUR COMPLETED FORM TO THE OFFICE OF MANAGEMENT AND BUDGET.
SEND IT TO THE ADDRESS PROVIDED BY THE SPONSORING AGENCY.**

NOTE: Certain of these assurances may not be applicable to your project or program. If you have questions, please contact the awarding agency. Further, certain Federal awarding agencies may require applicants to certify to additional assurances. If such is the case, you will be notified.

As the duly authorized representative of the applicant, I certify that the applicant:

1. Has the legal authority to apply for Federal assistance and the institutional, managerial and financial capability (including funds sufficient to pay the non-Federal share of project cost) to ensure proper planning, management and completion of the project described in this application.
2. Will give the awarding agency, the Comptroller General of the United States and, if appropriate, the State, through any authorized representative, access to and the right to examine all records, books, papers, or documents related to the award; and will establish a proper accounting system in accordance with generally accepted accounting standards or agency directives.
3. Will establish safeguards to prohibit employees from using their positions for a purpose that constitutes or presents the appearance of personal or organizational conflict of interest, or personal gain.
4. Will initiate and complete the work within the applicable time frame after receipt of approval of the awarding agency.
5. Will comply with the Intergovernmental Personnel Act of 1970 (42 U.S.C. §§4728-4763) relating to prescribed standards for merit systems for programs funded under one of the 19 statutes or regulations specified in Appendix A of OPM's Standards for a Merit System of Personnel Administration (5 C.F.R. 900, Subpart F).
6. Will comply with all Federal statutes relating to nondiscrimination. These include but are not limited to: (a) Title VI of the Civil Rights Act of 1964 (P.L. 88-352) which prohibits discrimination on the basis of race, color or national origin; (b) Title IX of the Education Amendments of 1972, as amended (20 U.S.C. §§1681-1683, and 1685-1686), which prohibits discrimination on the basis of sex; (c) Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. §794), which prohibits discrimination on the basis of handicaps; (d) the Age Discrimination Act of 1975, as amended (42 U.S.C. §§6101-6107), which prohibits discrimination on the basis of age; (e) the Drug Abuse Office and Treatment Act of 1972 (P.L. 92-255), as amended, relating to nondiscrimination on the basis of drug abuse; (f) the Comprehensive Alcohol Abuse and Alcoholism Prevention, Treatment and Rehabilitation Act of 1970 (P.L. 91-616), as amended, relating to nondiscrimination on the basis of alcohol abuse or alcoholism; (g) §§523 and 527 of the Public Health Service Act of 1912 (42 U.S.C. §§290 dd-3 and 290 ee 3), as amended, relating to confidentiality of alcohol and drug abuse patient records; (h) Title VIII of the Civil Rights Act of 1968 (42 U.S.C. §§3601 et seq.), as amended, relating to nondiscrimination in the sale, rental or financing of housing; (i) any other nondiscrimination provisions in the specific statute(s) under which application for Federal assistance is being made; and, (j) the requirements of any other nondiscrimination statute(s) which may apply to the application.
7. Will comply, or has already complied, with the requirements of Titles II and III of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646) which provide for fair and equitable treatment of persons displaced or whose property is acquired as a result of Federal or federally-assisted programs. These requirements apply to all interests in real property acquired for project purposes regardless of Federal participation in purchases.
8. Will comply, as applicable, with provisions of the Hatch Act (5 U.S.C. §§1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

9. Will comply, as applicable, with the provisions of the Davis-Bacon Act (40 U.S.C. §§276a to 276a-7), the Copeland Act (40 U.S.C. §276c and 18 U.S.C. §874), and the Contract Work Hours and Safety Standards Act (40 U.S.C. §§327-33), regarding labor standards for federally-assisted construction subagreements.
10. Will comply, if applicable, with flood insurance purchase requirements of Section 102(a) of the Flood Disaster Protection Act of 1973 (P.L. 93-234) which requires recipients in a special flood hazard area to participate in the program and to purchase flood insurance if the total cost of insurable construction and acquisition is \$10,000 or more.
11. Will comply with environmental standards which may be prescribed pursuant to the following: (a) institution of environmental quality control measures under the National Environmental Policy Act of 1969 (P.L. 91-190) and Executive Order (EO) 11514; (b) notification of violating facilities pursuant to EO 11738; (c) protection of wetlands pursuant to EO 11990; (d) evaluation of flood hazards in floodplains in accordance with EO 11988; (e) assurance of project consistency with the approved State management program developed under the Coastal Zone Management Act of 1972 (16 U.S.C. §§1451 et seq.); (f) conformity of Federal actions to State (Clean Air) Implementation Plans under Section 176(c) of the Clean Air Act of 1955, as amended (42 U.S.C. §§7401 et seq.); (g) protection of underground sources of drinking water under the Safe Drinking Water Act of 1974, as amended (P.L. 93-523); and, (h) protection of endangered species under the Endangered Species Act of 1973, as amended (P.L. 93-205).
12. Will comply with the Wild and Scenic Rivers Act of 1968 (16 U.S.C. §§1271 et seq.) related to protecting components or potential components of the national wild and scenic rivers system.
13. Will assist the awarding agency in assuring compliance with Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. §470), EO 11593 (identification and protection of historic properties), and the Archaeological and Historic Preservation Act of 1974 (16 U.S.C. §§469a-1 et seq.).
14. Will comply with P.L. 93-348 regarding the protection of human subjects involved in research, development, and related activities supported by this award of assistance.
15. Will comply with the Laboratory Animal Welfare Act of 1966 (P.L. 89-544, as amended, 7 U.S.C. §§2131 et seq.) pertaining to the care, handling, and treatment of warm blooded animals held for research, teaching, or other activities supported by this award of assistance.
16. Will comply with the Lead-Based Paint Poisoning Prevention Act (42 U.S.C. §§4801 et seq.) which prohibits the use of lead-based paint in construction or rehabilitation of residence structures.
17. Will cause to be performed the required financial and compliance audits in accordance with the Single Audit Act Amendments of 1996 and OMB Circular No. A-133, "Audits of States, Local Governments, and Non-Profit Organizations."
18. Will comply with all applicable requirements of all other Federal laws, executive orders, regulations, and policies governing this program.


SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL

TITLE

Sandra M. Dowdy
Contracts and Grants Analyst

APPLICANT ORGANIZATION

THE REGENTS OF THE UNIVERSITY
OF CALIFORNIA

DATE SUBMITTED

MAY 12 2000

APPLICATION FOR FEDERAL ASSISTANCE

OMB Approval No. 0348-0043

1. DATE SUBMITTED 5-15-00		Applicant Identifier
2. DATE RECEIVED BY STATE		State Application Identifier
3. DATE RECEIVED BY FEDERAL AGENCY		Federal Identifier

APPLICANT INFORMATION

1. Name: Joseph J. Cech, Jr.	Organizational Unit: University of California, Davis
2. Address (give city, county, State, and zip code): Dept. Wildlife, Fish, and Conservation Biology University of California, Davis Davis, Yolo County, CA 95616	3. Name and telephone number of person to be contacted on matters involving this application (give area code): Joseph J. Cech, Jr. 530-752-3103

EMPLOYER IDENTIFICATION NUMBER (EIN):

94-6036494

TYPE OF APPLICATION:

☒ New ☐ Continuation ☐ Revision

4. Revision, enter appropriate letter(s) in box(es)

5. Increase Award B. Decrease Award C. Increase Duration
6. Decrease Duration Other (specify):

CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER:

XX-XXXX

TITLE:

AREAS AFFECTED BY PROJECT (Cities, Counties, States, etc.):

Yolo County

7. PREVIOUS PROJECT	14. CONGRESSIONAL DISTRICTS OF:
---------------------	---------------------------------

8. Start Date 4-1-01	9. Ending Date 3-31-03	10. a. Applicant Congressional District # 3	11. b. Project Congressional District # 3
-------------------------	---------------------------	--	--

ESTIMATED FUNDING:

Federal	\$ 2,271,637	00
Applicant	\$	00
State	\$	00
Local	\$	00
Other	\$	00
Program Income	\$	00
TOTAL	\$ 2,271,637	00

16. IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?

a. YES. THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:

DATE

b. No. ☐ PROGRAM IS NOT COVERED BY E. O. 12372
☐ OR PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

17. IS THE APPLICANT DELINQUENT ON ANY FEDERAL DEBT?

☐ Yes If "Yes," attach an explanation. ☒ No

18. TO THE BEST OF MY KNOWLEDGE AND BELIEF, ALL DATA IN THIS APPLICATION/PREAPPLICATION ARE TRUE AND CORRECT, THE DOCUMENT HAS BEEN DULY AUTHORIZED BY THE GOVERNING BODY OF THE APPLICANT AND THE APPLICANT WILL COMPLY WITH THE ATTACHED ASSURANCES IF THE ASSISTANCE IS AWARDED.

19. Type Name of Authorized Representative	20. Title Sandra M. Dowdy Contracts and Grants Analyst	21. c. Telephone Number (530) 752-2075
22. Signature of Authorized Representative Sandra M. Dowdy		23. e. Date Signed MAY 12 2000

24. Edition Usable

25. Authorized for Local Reproduction

Standard Form 424 (Rev. 7-97)
Prescribed by OMB Circular A-102

BUDGET INFORMATION - Non-Instruction Programs

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1. Task 1, Fish Treadmill Operations		\$	\$	\$ 776,265	\$ 0	\$ 776,265
2. Task 2, Biological Studies				1,072,755	0	1,072,755
3. Task 3, Fish Collection				358,211	0	358,211
4. Task 4, Project Management				34,206	0	34,206
5. Totals		\$	\$	\$ 2,241,437	\$ 0	\$ 2,241,437

SECTION B - BUDGET CATEGORIES

Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY				Total (b)
	(1)	(2)	(3)	(4)	
a. Personnel	\$ 412,559	\$ 511,920	\$ 197,860	\$ 17,880	\$ 1,140,219
b. Fringe Benefits	66,017	121,550	30,440	5,350	223,357
c. Travel	0	16,000	42,180	0	58,180
d. Equipment	0	30,200	0	0	30,200
e. Supplies	27,800	73,000	14,760	0	115,560
1. Contractual CDFG Overhead, 17.3%	0	0	49,346	0	49,346
g. Construction	0	0	0	0	0
h. Other Student Fee Remissions	30,534	9,000	0	0	39,534
i. Total Direct Charges (sum of 6a-6h)	536,910	761,670	334,586	23,230	1,656,396
j. Indirect Charges	239,355	341,285	23,625	10,976	615,241
k. TOTALS (sum of 6i and 6j)	\$ 776,265	\$ 1,102,955	\$ 358,211	\$ 34,206	\$ 2,271,627
7. Program Income	\$ 0	\$ 0	\$ 0	\$ 0	\$ 0

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Standard Form 424A (Rev. 7-87)
Prescribed by OMB Circular A-102

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e) TOTALS
8. Task 1, Fish Treadmill Operations	\$ 0	\$ 0	\$ 0	\$ 0
9. Task 2, Biological Studies	12,739	0	0	12,739
10. Task 3, Fish Collection	0	0	0	0
11. Task 4, Project Management	0	0	0	0
12. TOTAL (sum of lines 8-11)	\$ 12,739	\$ 0	\$ 0	\$ 12,739

SECTION D - FORECASTED CASH NEEDS				
	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter
13. Federal	\$ 1,144,727	\$ 308,832	\$ 278,632	\$ 278,632
14. Non-Federal	12,739	3,185	3,185	3,185
15. TOTAL (sum of lines 13 and 14)	\$ 1,157,466	\$ 312,017	\$ 281,817	\$ 281,817

SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT				
(a) Grant Program	FUTURE FUNDING PERIODS (Years)			
	(b) First	(c) Second	(d) Third	(e) Fourth
16. Task 1, Fish Treadmill Operations	\$ 99,860	\$ 99,860	\$ 99,860	\$ 99,859
17. Task 2, Biological Studies	130,247	130,247	130,247	130,247
18. Task 3, Fish Collection	44,824	44,823	44,823	44,823
19. Task 4, Project Management	4,428	4,254	4,254	4,254
20. TOTAL (sum of lines 16-19)	\$ 281,859	\$ 281,684	\$ 281,684	\$ 281,683

SECTION F - OTHER BUDGET INFORMATION	
21. Direct Charges:	\$1,656,396
22. Indirect Charges:	\$615,241

23. Remarks:



State of California - The Resources Agency

GRAY DAVIS, Governor

DEPARTMENT OF FISH AND GAME

<http://www.dfg.ca.gov>

Central Valley Bay-Delta Branch
4001 N. Wilson Way
Stockton, CA 95205

May 10, 2000


Joseph J. Cech, Jr.
Department of Wildlife, Fish, and Conservation Biology
University of California
Davis, CA 95616

Dear Dr. Cech:

We agree to provide subcontracted services (from 4/1/01 to 3/31/03) to the University of California, Davis, regarding the proposed CALFED contract entitled "Fish Treadmill-Developed Fish-Screen Criteria for Native Sacramento-San Joaquin Watershed Fishes". These services would consist of assistance with fish capture activities as described in the project proposal (Task 3). In return for these services, the California Department of Fish and Game will be paid \$169,793 per year for two years (through UC Davis), as shown in the budget section of the project proposal (Task 3). The California Department of Fish and Game will commence services upon receiving a fully executed sub-contract from UC Davis. With the sub-contract and a delta smelt take authorization in place, the services will commence. If you have any questions concerning this matter, please contact Mr. Geir Aasen at (209) 948-7800 or gaasen@delta.dfg.ca.gov.

Sincerely,


Dan Odenweller
CDFG Investigator


Alan Baracco
CDFG Institutional Official

cc: Dr. Perry Herrgesell

Conserving California's Wildlife Since 1870

UNIVERSITY OF CALIFORNIA, DAVIS

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SANTA BARBARA • SANTA CRUZ

COLLEGE OF AGRICULTURAL AND
ENVIRONMENTAL SCIENCES
AGRICULTURAL EXPERIMENT STATION
COOPERATIVE EXTENSION

DEPARTMENT OF WILDLIFE, FISH AND CONSERVATION BIOLOGY
ONE SHIELDS AVENUE
DAVIS, CALIFORNIA 95616-8751
FAX (530) 752-4154

May 12, 2000

Yolo County Board of Supervisors
625 Court
Woodland, CA 95695-3448

Dear Sir or Madam,

This letter to inform you that I have submitted a proposal entitled "Fish Treadmill-Developed Fish Screen Criteria for Native Sacramento-San Joaquin Watershed Fishes" to the CALFED Ecosystem Restoration Program. The work described in the proposal will be conducted at the University of California, Davis, in Yolo County.

Sincerely,

A handwritten signature in dark ink, appearing to read "Joseph J. Cech, Jr.", is written over the typed name.

Joseph J. Cech, Jr.
Professor

cc: CALFED Bay/Delta Program

Environmental Compliance Checklist

All applicants must fill out this Environmental Compliance Checklist. Applications must contain answers to the following questions to be responsive and to be considered for funding. Failure to answer these questions and include them with the application will result in the application being considered nonresponsive and not considered for funding.

1. Do any of the actions included in the proposal require compliance with either the California Environmental Quality Act (CEQA), the National Environmental Policy Act (NEPA), or both?

YES

 X
NO

2. If you answered yes to # 1, identify the lead governmental agency for CEQA/NEPA compliance.

Lead Agency

3. If you answered no to # 1, explain why CEQA/NEPA compliance is not required for the actions in the proposal.

Project consists of research, and does not include environmental modifications or alterations. Fish specimens will be collected under existing or pending scientific collecting permits/agreements.

4. If CEQA/NEPA compliance is required, describe how the project will comply with either or both of these laws. Describe where the project is in the compliance process and the expected date of completion.

5. Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?

YES

 X
NO

If yes, the applicant must attach written permission for access from the relevant property owner(s). Failure to include written permission for access may result in disqualification of the proposal during the review process. Research and monitoring field projects for which specific field locations have not been identified will be required to provide access needs and permission for access with 30 days of notification of approval.

6. Please indicate what permits or other approvals may be required for the activities contained in your proposal. Check all boxes that apply.

LOCAL

Conditional use permit _____

Variance _____

Subdivision Map Act approval _____

Grading permit _____

General plan amendment _____

Specific plan approval _____

Rezone _____

Williamson Act Contract _____

cancellation _____

Other _____

(please specify) _____

None required ☒

STATE

CESA Compliance _____

(CDFG)

Streambed alteration permit _____

(CDFG)

CWA § 401 certification _____

(RWQCB)

Coastal development permit _____

(Coastal Commission/BCDC)

Reclamation Board approval _____

Notification _____

(DPC, BCDC)

Other _____

(please specify) _____

None required ☒

FEDERAL

ESA Consultation _____

(USFWS)

Rivers & Harbors Act permit _____

(ACOE)

CWA § 404 permit _____

(ACOE)

Other _____

(please specify) _____

None required ☒

DPC = Delta Protection Commission

CWA = Clean Water Act

CESA = California Endangered Species Act

USFWS = U.S. Fish and Wildlife Service

ACOE = U.S. Army Corps of Engineers

ESA = Endangered Species Act

CDFG = California Department of Fish and Game

RWQCB = Regional Water Quality Control Board

BCDC = Bay Conservation and Development Comm.

Land Use Checklist

All applicants must fill out this Land Use Checklist for their proposal. Applications must contain answers to the following questions to be responsive and to be considered for funding. Failure to answer these questions and include them with the application will result in the application being considered nonresponsive and not considered for funding.

1. Do the actions in the proposal involve physical changes to the land (i.e. grading, planting vegetation, or breaching levees) or restrictions in land use (i.e. conservation easement or placement of land in a wildlife refuge)?

YES

X
NO

2. If NO to # 1, explain what type of actions are involved in the proposal (i.e., research only, planning only).

Project involves only research.

3. If YES to # 1, what is the proposed land use change or restriction under the proposal?

4. If YES to # 1, is the land currently under a Williamson Act contract?

YES

NO

If YES to # 1, answer the following:

Current land use _____

Current zoning _____

Current general plan designation _____

6. If YES to #1, is the land classified as Prime Farmland, Farmland of Statewide Importance or Unique Farmland on the Department of Conservation Important Farmland Maps?

YES

NO

DON'T KNOW

7. If YES to # 1, how many acres of land will be subject to physical change or land use restrictions under the proposal?

8. If YES to # 1, is the property currently being commercially farmed or grazed?

YES

NO

9. If YES to #8, what are

the number of employees/acre _____

the total number of employees _____

10. Will the applicant acquire any interest in land under the proposal (fee title or a conservation easement)?

YES

 X
NO

11. What entity/organization will hold the interest? _____

12. If YES to # 10, answer the following:

Total number of acres to be acquired under proposal _____

Number of acres to be acquired in fee _____

Number of acres to be subject to conservation easement _____

13. For all proposals involving physical changes to the land or restriction in land use, describe what entity or organization will:

manage the property _____

provide operations and maintenance services _____

conduct monitoring _____

14. For land acquisitions (fee title or easements), will existing water rights also be acquired?

YES

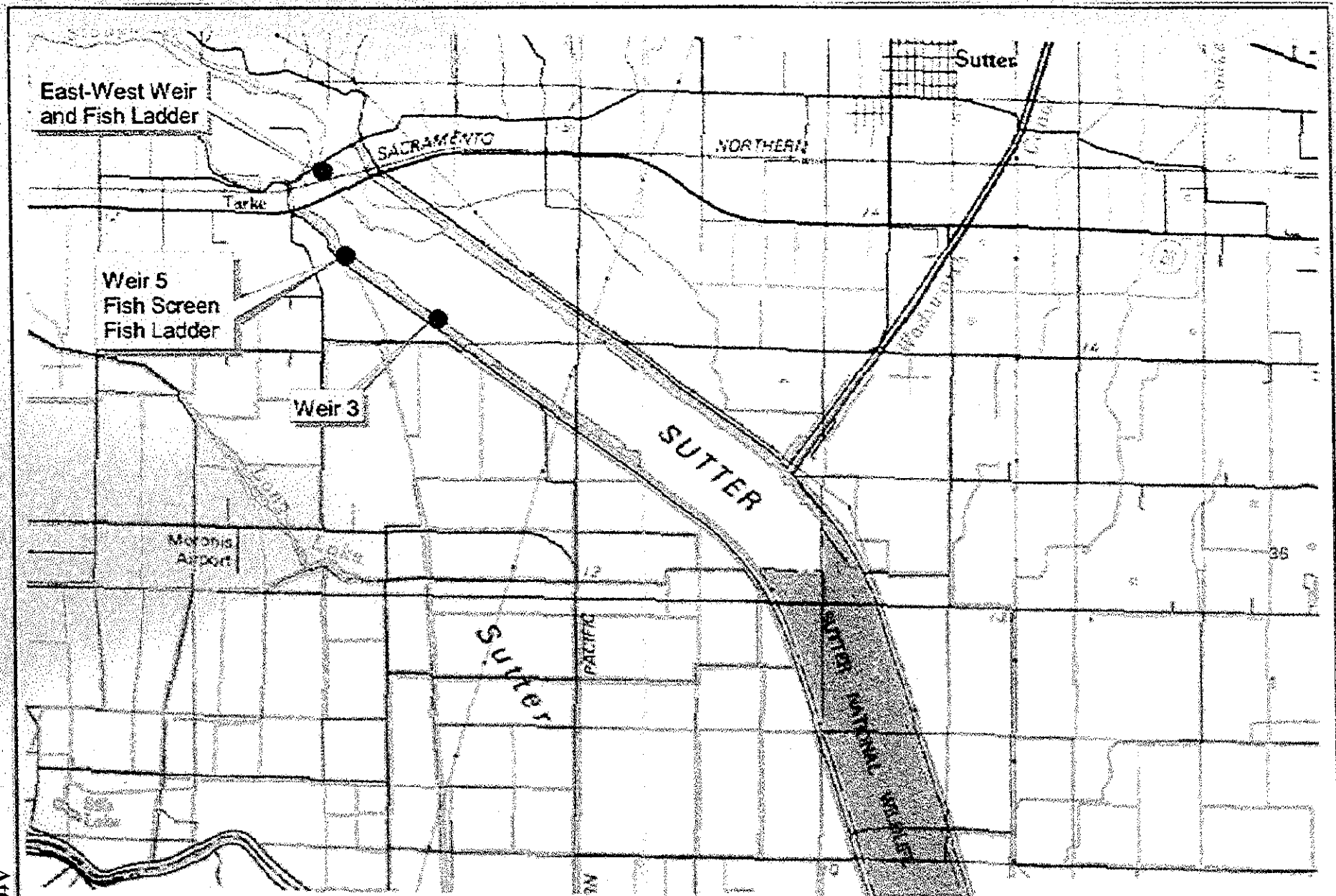
NO

15. Does the applicant propose any modifications to the water right or change in the delivery of the water?

YES

 X
NO

16. If YES to # 15, describe _____

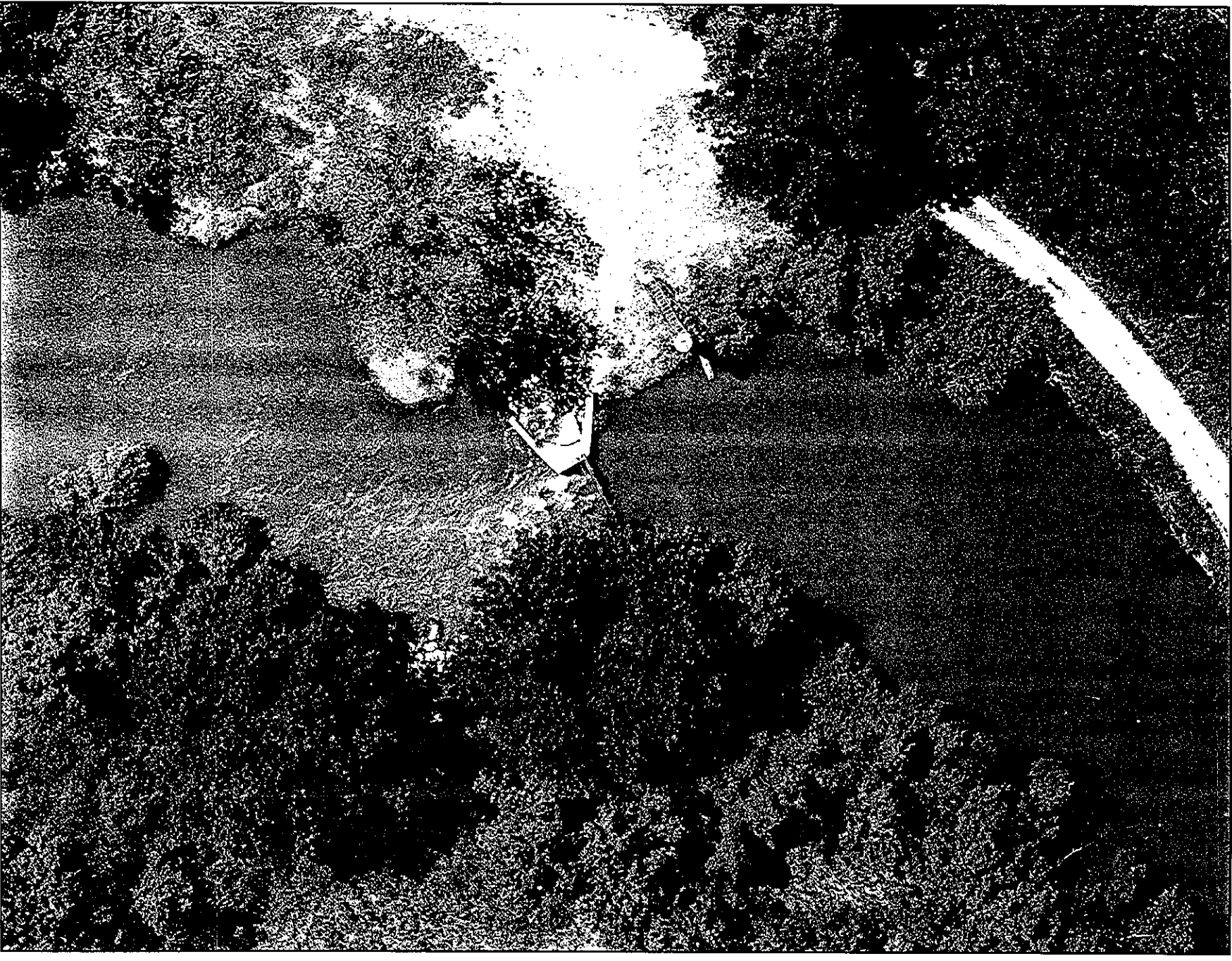


Lower Butte - West Side Project

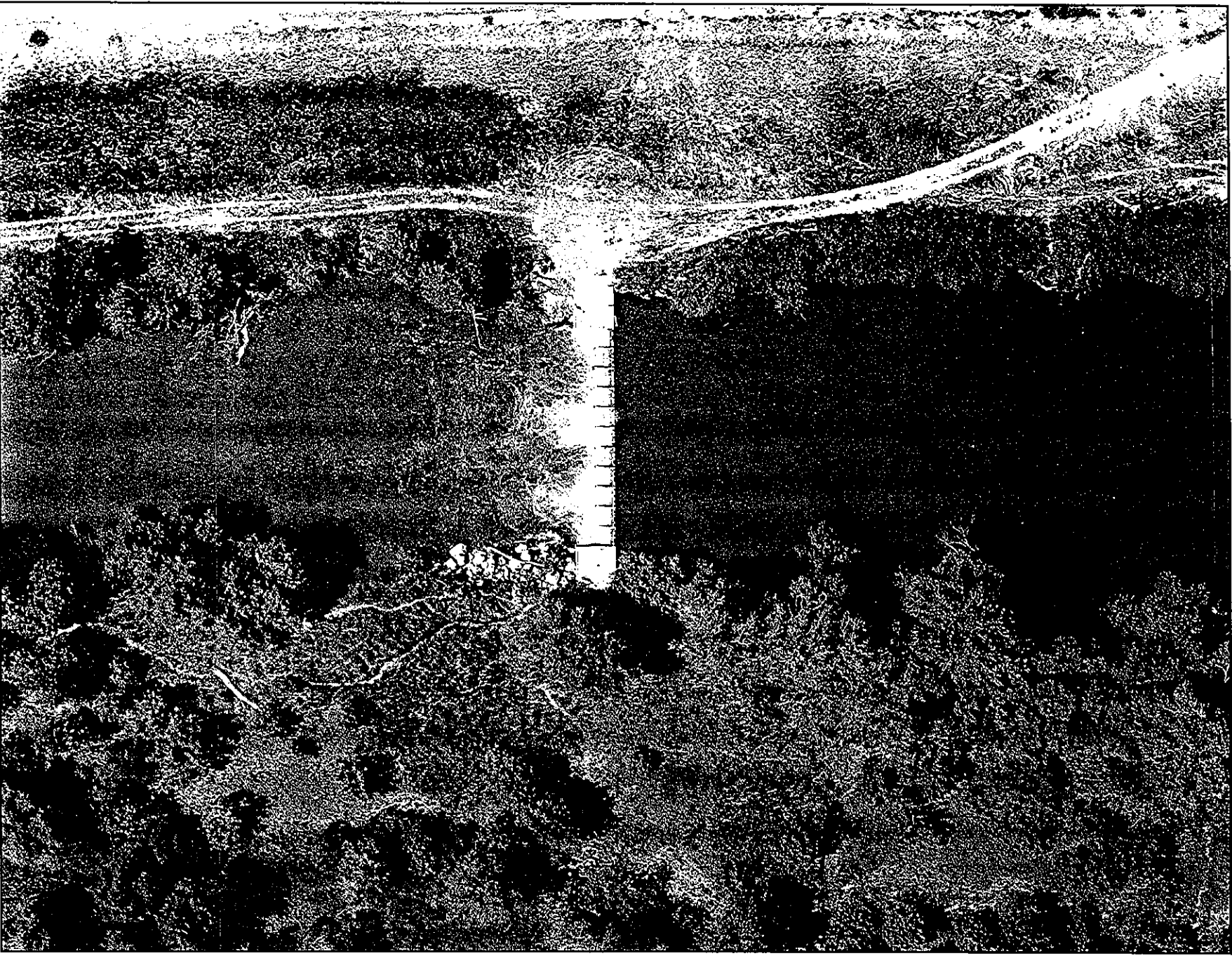
Ducks Unlimited

0 0.2 Miles



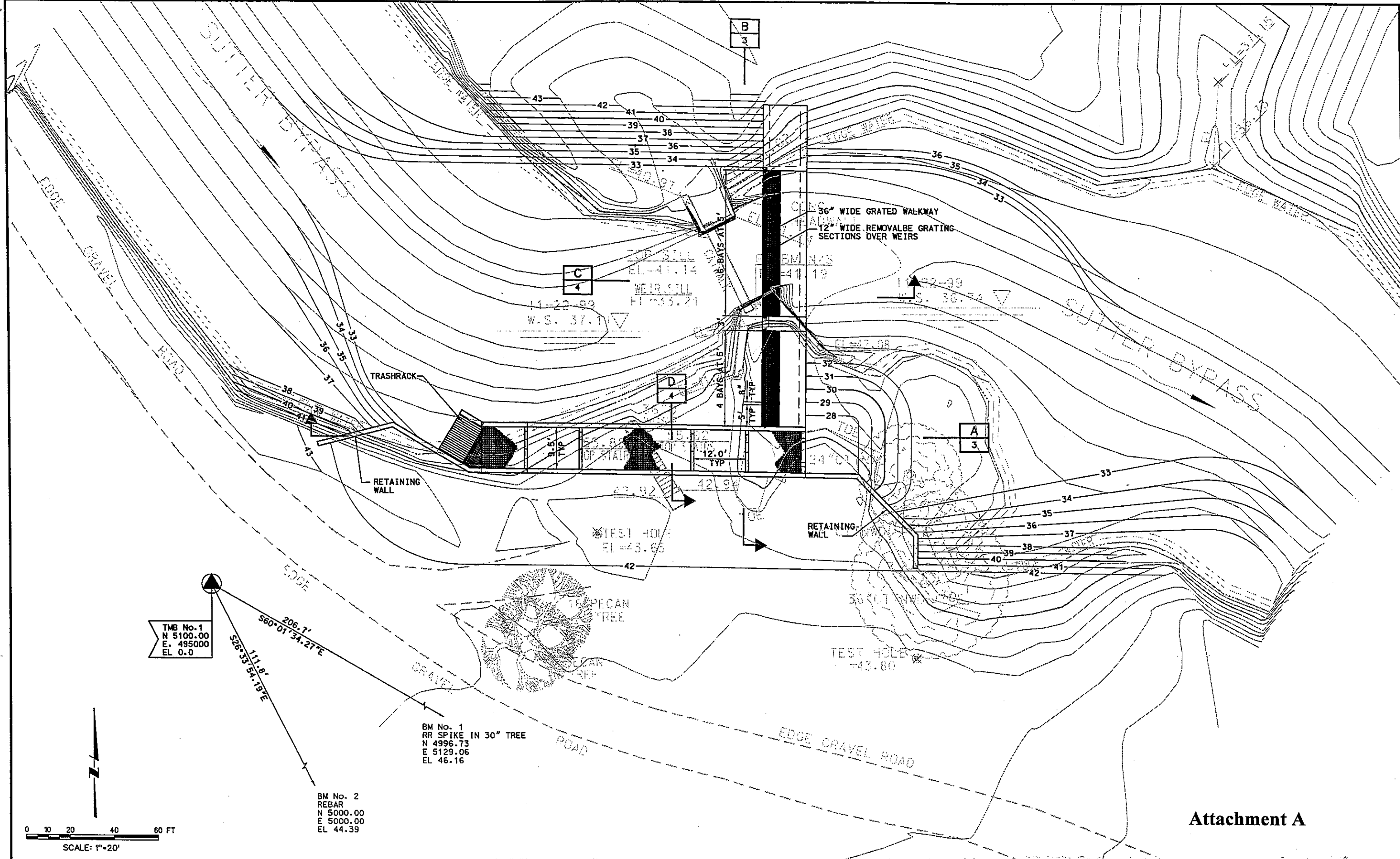


East-West Diversion Weir



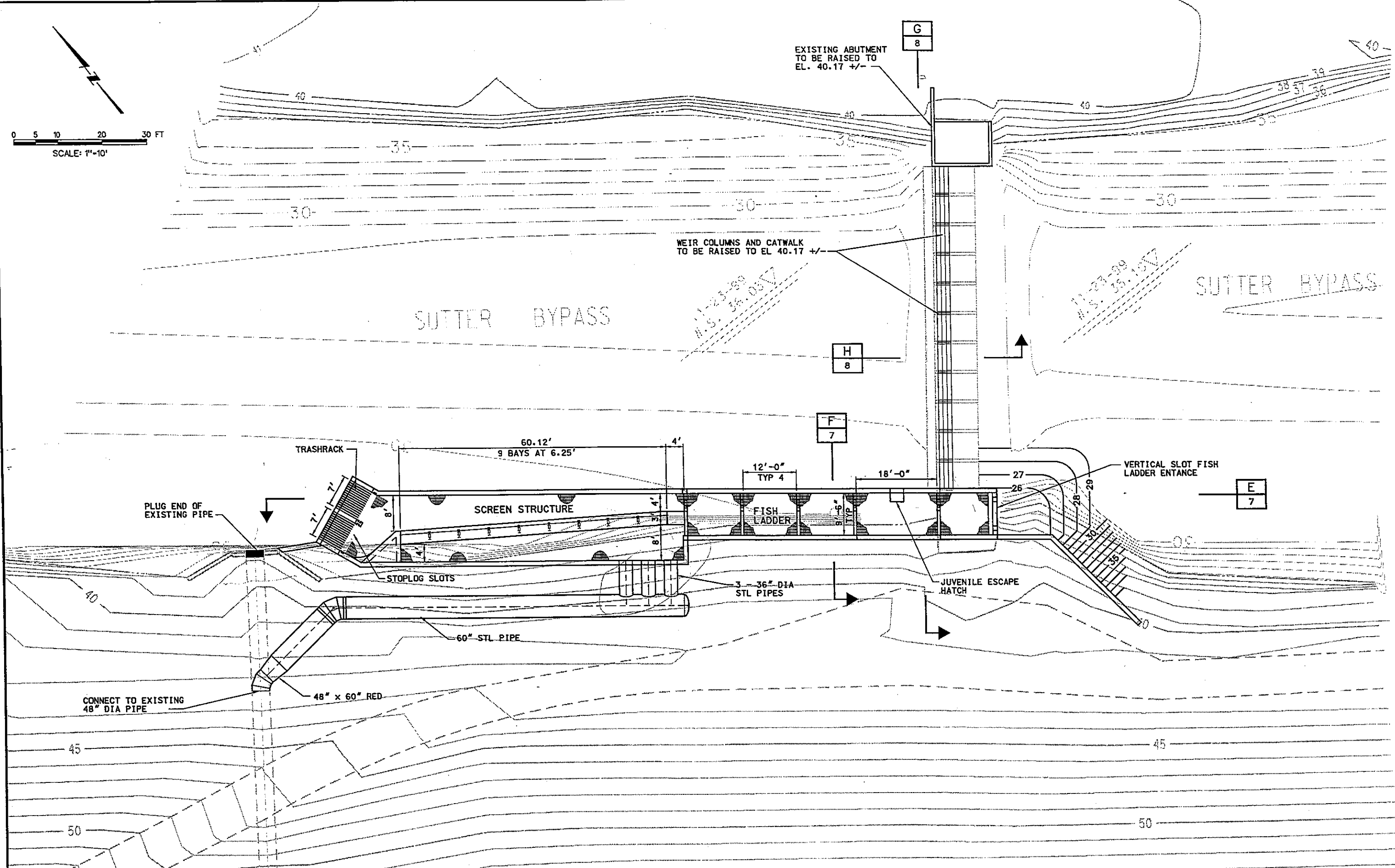
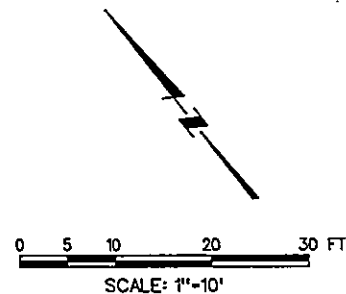
Weir 5





Attachment A

				SCALE 1"=10'	<div>WARNING</div> <div>0 1/2 1</div> <div>IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE</div>	DESIGNED _____	SUBMITTED BY _____		<div></div> <div>MONTGOMERY WATSON</div> <div>Bellevue, Washington</div>	<div>DUCKS UNLIMITED BUTTE SLOUGH</div>	<div>EAST-WEST DIVERSION SITE PLAN</div>	SHEET 1
						DRAWN _____	_____ LICENSE NO. _____ DATE _____					
						CHECKED _____	_____ LICENSE NO. _____ DATE _____					
REV	DATE	BY	DESCRIPTION									



REV	DATE	BY	DESCRIPTION

SCALE

WARNING

 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED	
DRAWN	
CHECKED	

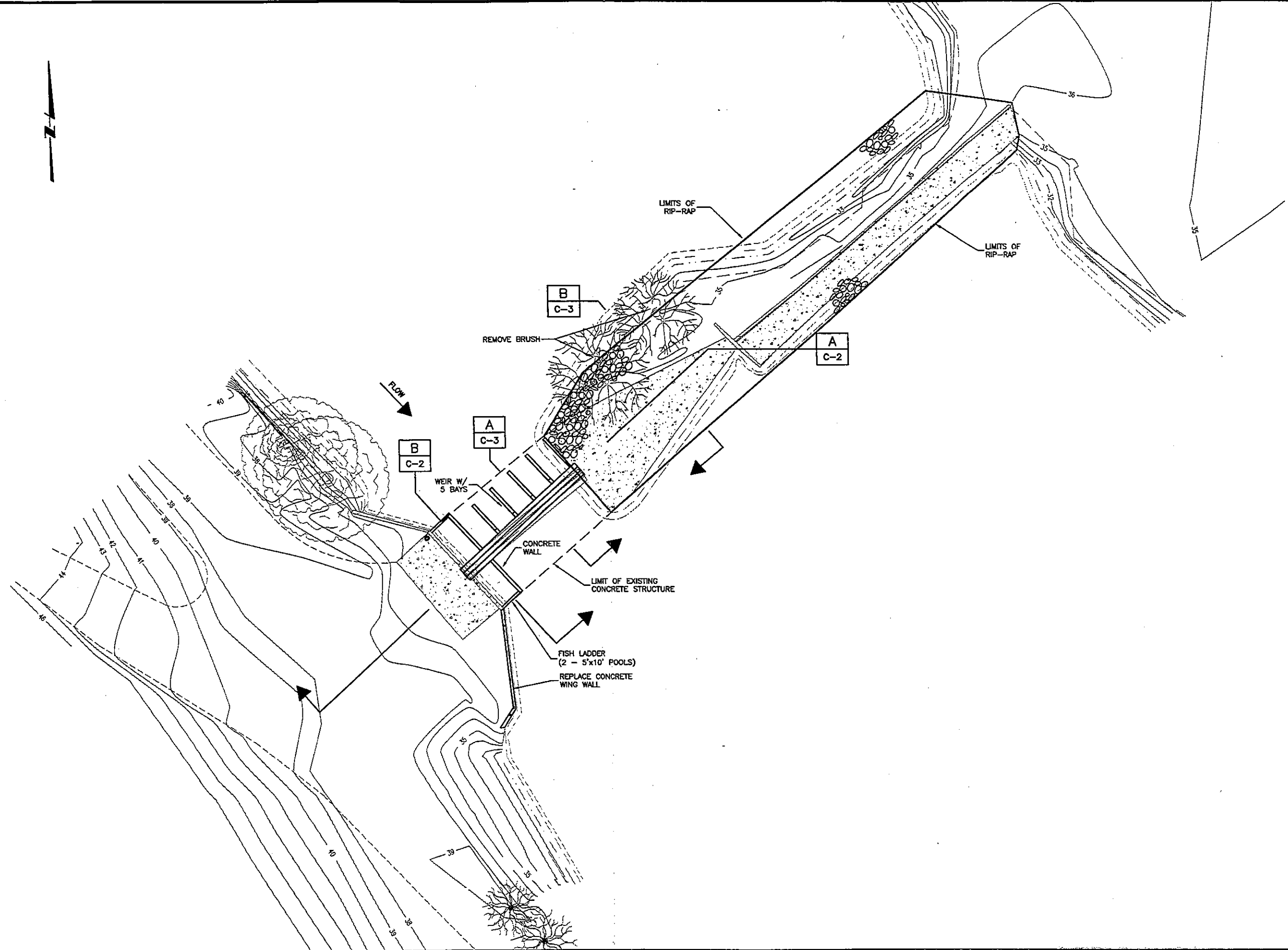
SUBMITTED BY	
LICENSE NO.	
DATE	
LICENSE NO.	
DATE	

MONTGOMERY WATSON
 Bellevue, Washington

DUCKS UNLIMITED
 BUTTE SLOUGH ...

WEIR NO. 5
 SITE PLAN

SHEET
5



REV	DATE	BY	DESCRIPTION

SCALE:
1" = 10'

WARNING
0 1/2 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE.

DESIGNED
DRAWN M. HARGROVE
CHECKED

SUBMITTED
PROJECT ENGINEER
RECOMMENDED
MONTGOMERY WATSON
R. C. E. NO. DATE



MONTGOMERY WATSON
Sacramento, California



LOWER BUTTE CREEK
WEST-SIDE SUTTER BYPASS PROJECT
WEIR 3 SITE PLAN

SHEET
C-1